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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Home Power

THE HANDS-ON JOURNAL OF HOME-MADE POWER

People

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Stan Krute
Clifford Mossberg
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Contents

Access

Home Power Magazine
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Think About It

"Endless money forms the sinews of war."

Marcus Tullius Circero. 106 – 43 B.C.

Cover

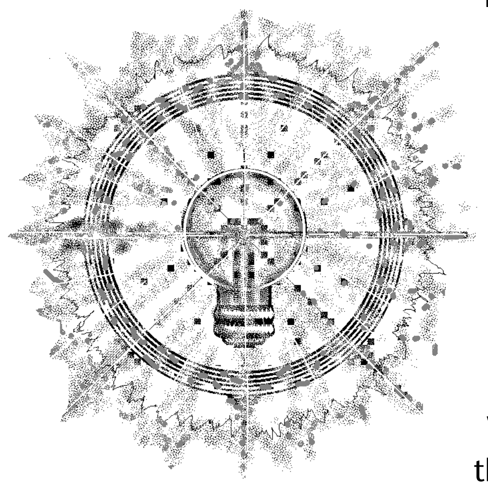
You don't have to live in a tipi to enjoy solar electricity. This beautiful home is powered by the sun. Story on page 40.

Photo by Richard Perez.

War on schedule

Saddam Hussein paid for his SCUDs, his nerve gas, his nukes, and his army with oil money.

Iraq has one source of income– oil. From the profits of selling this oil, Hussein and his associates bought a massive war machine. They bought SCUDs, MIG fighters, and tanks from the Soviet Union. They bought Mirage fighters and Exocet missiles from France. They bought chemical weapons plants from Germany. They bought nuclear breeders from Brazil. Oil money allows Iraq, a nation of less than 18 million population, to keep an army of over one million soldiers. A war machine of this magnitude costs billions of dollars. And it all came from oil.



Forty years ago Iraq could barely feed itself. I know this because I was there in 1952. I saw crushing poverty all around me. Now the Iraqis can afford to kill their neighbors and embroil the world in another war. All thanks to oil money, which is 98.6% of the Iraqis' national income.

Without oil money, Hussein would be just another sadistic tyrant in a world which has seen many of his kind. But it is Saddam's wealth that allows him to impose his madness on his neighbors. Without this wealth there would be no missiles, no tanks, no army, and no Gulf War.

Who bought this oil? Who gave Saddam Hussein the money for his war machine? We did. The industrialized nations of the world bought this oil. Countries like Japan, Germany, and the United States of America. In our feeding frenzy for fossil fuels, we didn't consider where the money was going. Iraq had the oil and we wanted it, so we bought it.

And now we are fighting another war. A war bought and paid for by the oil we used.

As long as we do the Dance of Dead Dinosaurs, we can expect more of the same. Our appetite for oil is far more expensive than we have ever realized. Latest figures indicate that the Gulf War is costing half a billion dollars daily. Add this to the oil–related environmental damages, and oil burning is indeed very expensive. And we continue to pay.

We now have working, renewable energy technologies that can reduce, and eventually eliminate, the use of oil as a fuel. These technologies aren't the "wave of the future". Many of us are using them today and have been doing so for years. And most of us have done it on a budget.

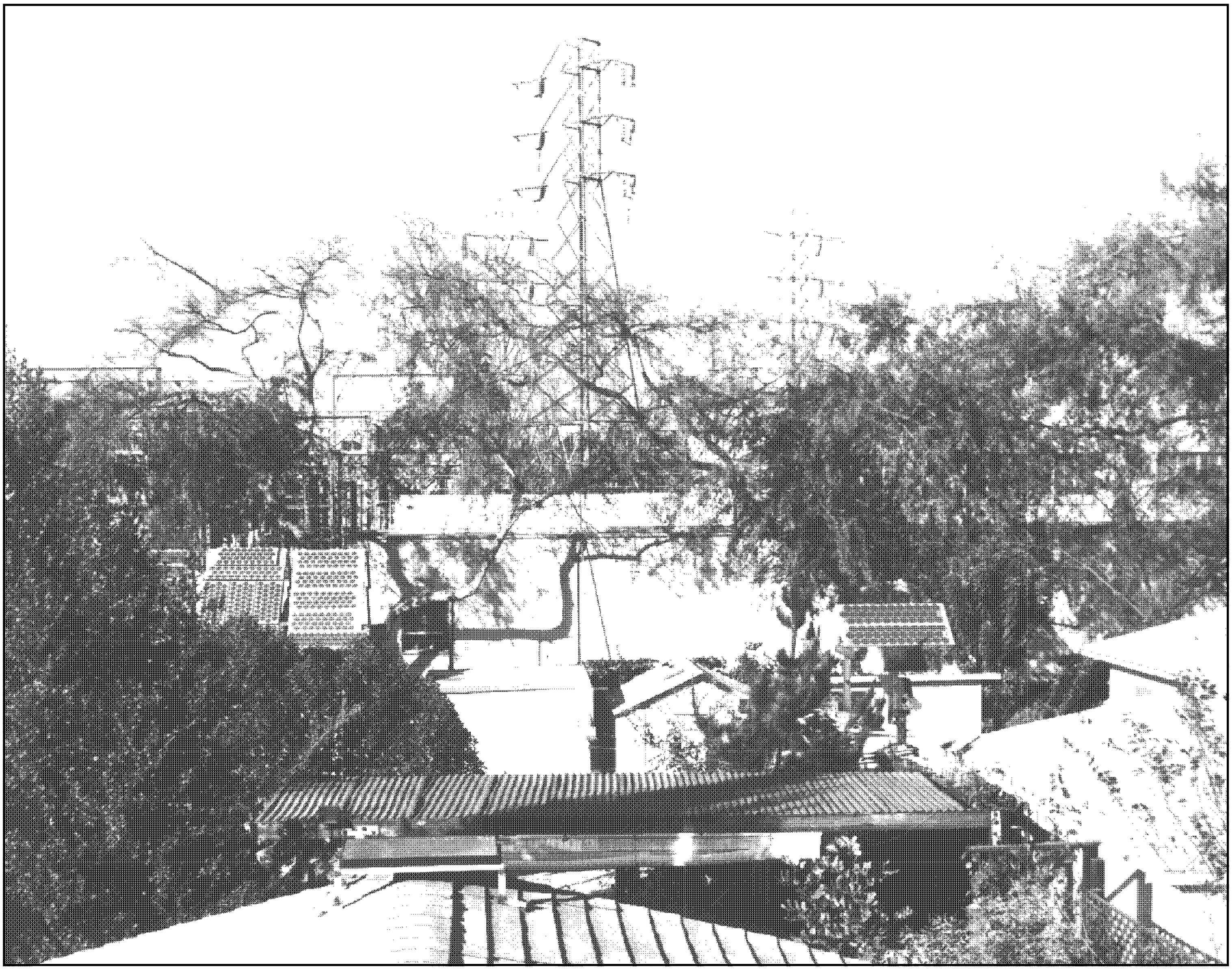
If even a fraction of the money poured into oil and its associated wars and pollution was spent on renewable energy we would be free of these problems.

Obviously, governments aren't going to be much help. They are part of the problem.

We can make a difference. Within the pages of Home Power you will find many energy alternatives and options. Use these options. Every PV panel that sees sunshine brings us all closer to freedom and a clean environment. Every hydro turbine operating brings us closer to peace. Every wind powered generator brings us closer to a world that is sustainable. We make the choice every time we pay the electric bill or fill up the car. What kind of world will you choose?

Richard Perez for the Whole Home Power Crew.

Special thanks to Kathy Fueston of the Yreka, California Public Library for looking up and relaying via telephone the straight facts about Iraq for us.



Above: John Drake's photography studio is powered by photovoltaic modules on the building's roof. John's solar powered system provides ultra-clean and ultra-reliable electricity and it's just a few feet from one of the largest commercial utility substations in southern California. PVs aren't just for country folks anymore. Photo by John Drake.

PVs in Downtown Long Beach, CA

John Drake

Here are some photographs of our photovoltaic setup. Currently we use PV power for ventilation in our house, workshop, washhouse and photo-lab. The building supporting the arrays is a close-up photography studio using low voltage DC for lighting and a 500 watt inverter for fluorescent lighting and electronic flash operation. Our motorcycle shed and photo-lab uses its power for battery maintenance, lighting, and radios.

System Info

Since the modules are a mix, I had to custom fabricate the support structures from stainless steel. Each array has its own 25 Ampere blocking diode and its frame is grounded with 6 gauge wire to an earth rod. The controller is a shunt-type Burkhardt Enermaxer. This Enermaxer uses externally mounted air heating elements, in a stainless steel enclosure, to dissipate excess power. The battery is an 800 Ampere-hour, lead-acid type.

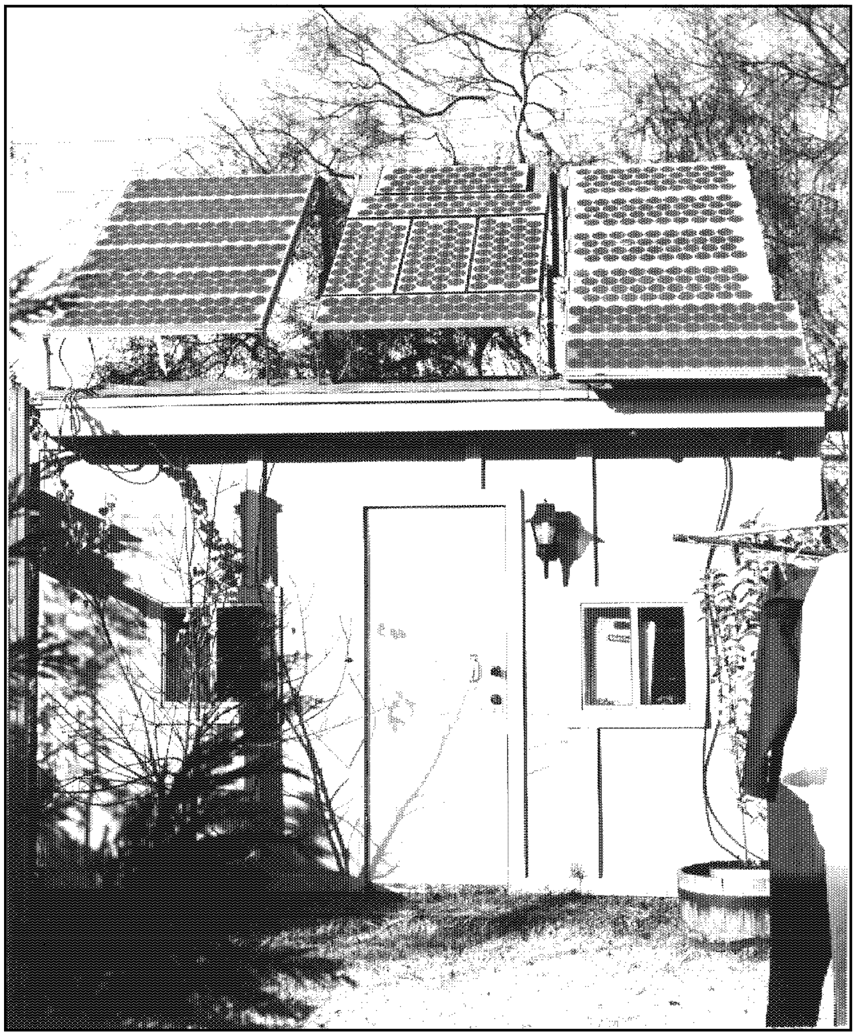
Our next step is to bring power into the house to run fluorescent lighting and ceiling fans in each room. It will also power a forced-air system and whole house fan.

The patio area uses a 700 Watt PV array regulated by an SCI-I charge controller. The battery is a 105 Ampere-hour sealed marine type. This system powers incandescent lights in the tool shed, Malibu lighting outdoors, fluorescent lights, bug killer lights and a waterfall pump.

We believe in solar energy even though we live in one of the largest cities in California. The facility behind our back fence is the Southern California Edison Co. Lighthipe sub-station, one of the largest in Southern California. We had an audience when I was loading the modules into the frames, and a lot of strange looks too.

ACCESS

John and Christine Drake, 1427 E. 68th St, Long Beach, CA 90805 • 213-423-4879.



Above: James Davenport's PV/Wind/Engine powered home in Wisconsin. One of the interesting features of James' system is his home-made 12 VDC freezer/refrigerator which uses about 15 Ampere-hours daily. This is 185 Watt-hours daily and that's less than one-third the power consumption of just about every factory-made refrigerator/freezer. Cost? About $500.

Refrigeration at Shady Hollow Farm

James Davenport

When I slid off to the hinterland of western Wisconsin in the mid-seventies, I didn't fully grasp how long of a break I would be taking from the highfalutin contrivances of the twentieth century. The first couple of years were strictly wood heat, wood cooking, and lots of kerosene lamps. The water was carried up the hill in two five gallon glucose buckets. We dug the outhouse down the path off in the woods. In time, as money put ahead would allow, the tech gap between Shady Hollow Farm and my electric co–op neighbors has shrunk. In the first year, a propane hot plate appeared, and soon after we attached the first old car battery to a car stereo.

Growth

The beginnings of our truly alternative household happened when car batteries died too quickly. We discovered the meaning of deep cycle. After a year of trucking multiple 12 Volt, 105 Ampere-Hour batteries around, we clearly saw the need for home power generation. Our first generator was a 200 Watt Wincharger, which was quickly followed by our first photovoltaic panel. With each step of increased generation came a mirror increase in consumption leading to the most recent step, REFRIGERATION.

The House in the Hollow

Our house is on the northwest edge of and halfway up a long grassy valley. This narrow valley (75 yards wide by 1/8 mile long) lies between two 150 foot tall oak covered hills. We built the house without any thought of photovoltaics, but fortunately we planned for lots of sun through the house's windows. The front of the house faces 30° East of South, which is down the valley. In this direction and from the house the trees are about 20° above the horizon. The winter's sun illuminates the PVs at about 11:00 AM and sets on the panels at 4:30 PM. During the winter, our shortest solar day is 5.5 hours long. I ended up mounting the photovoltaics facing 10° west of south (facing the sun at 12:45 PM).

System Equipment

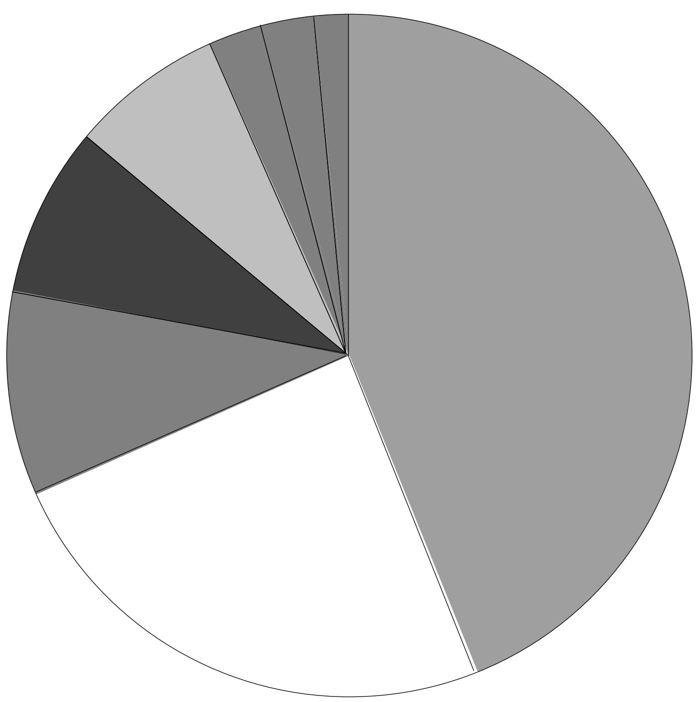
My neighbor discovered a source of used Exide lead-acid cells. I bought 24 used 2 Volt, glass–cased cells for the scrap price of 5¢

per pound. The cells measure 4 inches by 10 inches by 15 inches and weigh 50 pounds each. Each cell is rated at 120 Ampere-hours and the four packs give us a 12 Volt battery that holds 480 Ampere-hours. These cells have been in use here for five years and could well be five years older than that. The plates are looking pretty crude now and the cells don't hold a charge like they used to. The first set of batteries we used were four 12 Volt, 105 Ampere-hour deep cycle marine batteries. These died the death of deep cycling as mentioned above. All the photovoltaics were bought piecemeal over several years and they are controlled by an SCI-2, a 30 Ampere charge controller.

The wind machine is a nine year old Wincharger mounted about thirty feet in front of the house. The site limitations on wind power here are even greater than those on solar power. Placing the wind machine in the bottom of a long skinny valley limits the usable wind directions to two– either up valley or down valley. Fortunately, the wind in western Wisconsin often blows from the southwest. The Winco Wincharger will generate almost ten Amperes average all day before a cold front. A big storm here produces about 3,000 Watt-hours, with the ole' Wincharger producing as much as 25 Amperes at times. The drawback of the Wincharger is that the voltage increase during gusts will prematurely trip the solar charge controller forcing me to either keep resetting the controller or to shut down the Wincharger until the sun sets.

System Costs for Shady Hollow Farm

ITEM	COST	%
Ten assorted 32 Watt PV Panels	$1,800	43.96%
Wincharger 200	$1,000	24.42%
Honda 500 watt Generator	$400	9.77%
Heart 300 Inverter	$330	8.06%
Cables, Wire, Boxes, & Stuff	$300	7.33%
SCI–2 PV Charge Controller	$100	2.44%
Multimeters (Radio Shack)	$100	2.44%
Used Exide Batteries	$65	1.59%
Total	$4,095	



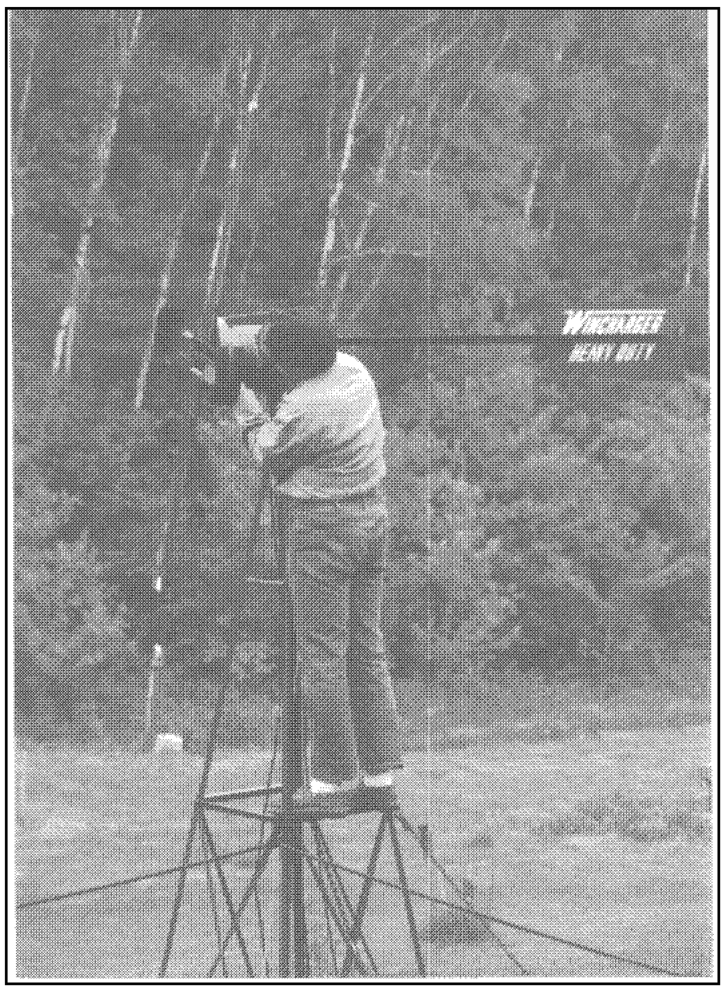
Before the batteries weakened and I added the freezer, I used to use my computer without much thought to the batteries. These days I usually run the eight year old Honda engine/generator when I use the computer. This old Honda consumes about half a gallon of gas during 4.5 hours of heavy use. I use a 120 vac charger that puts 15 Amperes into the batteries when the Honda is running. Sometimes when everything is producing (PVs, Wincharger and Honda generator) I put as many as 40 Amperes into the batteries.

System Loads

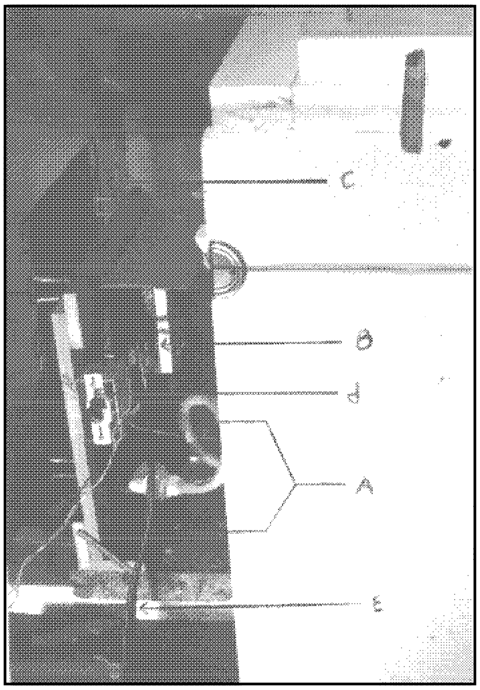
The computer system (including printer, monitor, and hard drive) consumes about 150 watts while operating. Incandescent lights are set up for most locations, but two 120 vac fluorescent lights are used in the main "always on" locations.

Refrigeration

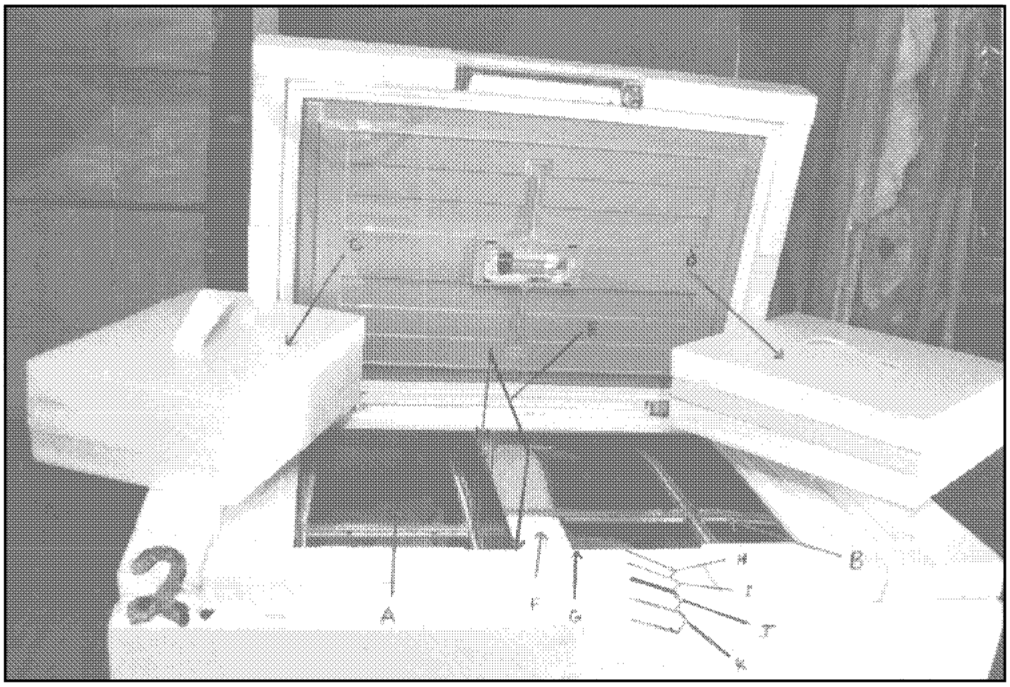
At first an old Servel gas unit served for a couple of cantankerous years, but when it started sucking propane too fast it was decommissioned. Meanwhile, using the normally cold 45° northwestern Wisconsin air provided both an intermittent winter



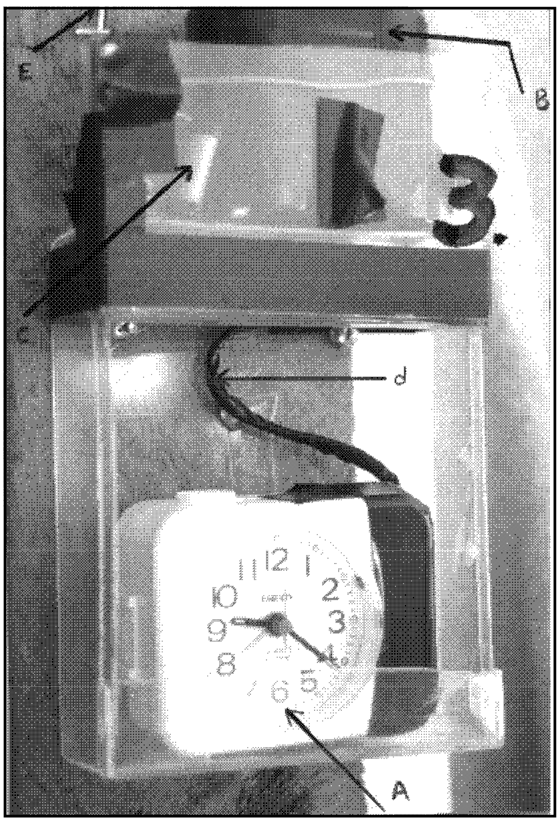
James up the tower reassembling the Winco after fixing some blade damage.



Above: Photo 1. Exterior showing: A-Compressor, B- Control,C-Compressor Coil, D-Thermostat, E- Wiring



Above: Photo 2. A- Freezer, B- Refrigerator, C & D -Foam interior lids, E & G-Plexiglas walls.



Above: Photo 3. A- Relay controlled battery operated clock, C- Diode, D- Relay.

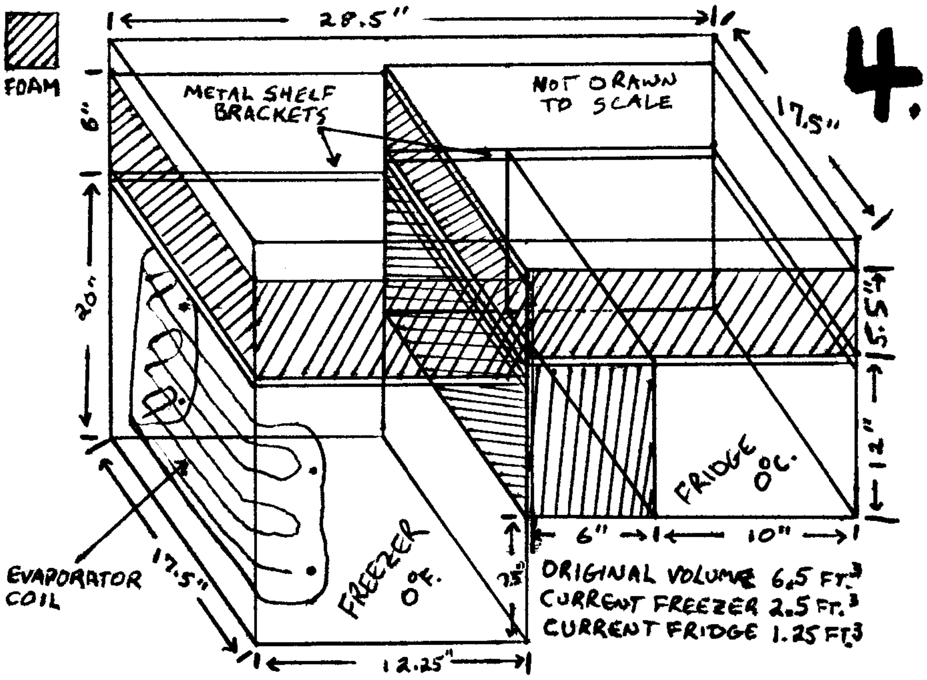
freezer and a most-of-the-time six month cooler. The rest of the year required 10 pound blocks of ice put in coolers in the basement. All the while I coveted the $1400.00, 14 cubic foot Sunfrost freezer/fridge but couldn't afford it. Last spring in Home Power #16's Homebrew section, Bob McCormick described his freezer built with the Danfoss 12 VDC compressor. I wanted to do it too! My neighbor and fellow alternative energy householder, Leon Meiseler, went to the energy fair in Amherst, WI and met Gunars Petersons who started Alternative Power and Light over in Cashton and who sells those same Danfoss compressors. This fall I bought one of his do-it-yourselfer kits which consists of the BD2.5, 4.5 amp, 12 VDC compressor motor with electronic control unit.

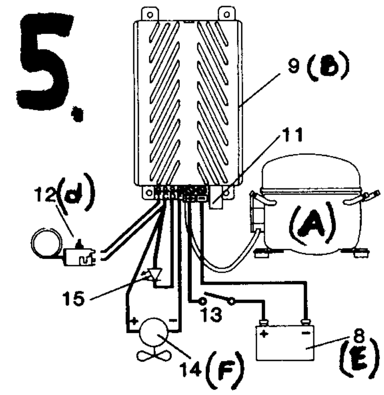
Parts

Finding the rest of the parts took awhile. I finally found a good top-opening "junker" freezer. It was an old 6.5 cubic foot Delmonico. It has a nice stainless steel interior box which I separated into freezer and fridge. I made dividing walls out of 1/4 inch smoked Plexiglas™. Two rectangles of steel shelf brackets were set into each of the two spaces, both holding the main Plexiglas™ divider rigidly and providing two bases for the two foam (interior) lids. The freezer side plug is 6" thick and the fridge side is 5.5" thick. The fridge space is placed on what was an above-the-compressor shelf in the Delmonico configuration. I wanted 12" of vertical space in the fridge so its foam lid ended up 1/2" thinner to fit.

Putting things together

The next part of the project was finding freezer coils that would match the BTU rating of the Danfoss BD2.5. This figure by the way is 185 BTUs, little enough to make many a refrigerator appliance parts man guffaw. After the third parts place gave me the same response, I called Danfoss and their tech person suggested I use a set of coils from a burnt out dorm fridge. This I found in my fridge guy's pile of appliance carcasses in back of his shop. The coils were really clean. I built a wood mounted, external compressor assembly that would hold everything out away from the box. Visible on photo 1 are the BD2.5 (A), the electronic unit (B), compressor coil (C), thermostat (D), #4 copper battery leads (E), and wires (F) leading to the diodes and clock up in my kitchen. The insulation used is 2 sheets (4x8) of 2", (R5) white styrene, and 3.5 sheets of 2" (R10) polyurethane foam. This was all glued together with PL 300, a glue for foam products. Originally the





Left: Figure 4. Construction diagram of the 12 VDC freezer/refrigerator.

Above: Figure 5. A pictorial schematic of the Freezer/Refrigerator system components. A-Danfoss Compressor, B- Control Unit, D-Thermostat, E- Battery, and F- Fan.

Delmonico had R5 insulation in its walls and lid. I increased it to R30 in its base and walls and (counting the interior 6" plugs) R50 in its roof. The freezer ends up holding 2.5 cubic feet and the fridge 1.25 cubic feet. The 6" foam barrier between the two is removable, creating a 4.5 cubic foot freezer if needed. The 3.75 cubic foot combo unit volume is dwarfed by the outside dimensions (44" high, 45" wide, 34" deep, 39 cubic feet total).

The Installation

The day it was installed I also had 50 pounds of fresh venison to put in so it was trial by fire. It took three days and four gallons of generator gasoline to freeze up that load with the thermostat set to coldest. It leveled out at -10°F in my then 50°F basement. Maintaining that required the compressor running 4.4 hours/day at a steady measured 4.5 amps, 20 AH/day. I don't need that cold of a freezer so for the last three weeks I have been turning back the thermostat slowly and measuring the performance with the clock assembly pictured in photo 3. It takes power from what would be the fan circuit on the Danfoss control unit and turns on both a green diode and a relay (Photo 3, D) controlled battery driven quartz clock (Photo 3, A). This $10.00 unit does the job of a $200.00 Amp–hour meter, as long as you know the current.

After two weeks of adjusting the thermostat, the system leveled out at a freezer temperature of 0°F, fridge 0°C, with the basement at 40°F. The motor was running 3.6 hours/day or 16.5 AH/day. I vented the outside air through four inch plastic tubing to drop cold air over the compressor coils. Three days after I adjusted the thermostat again and found the upper temperature limit reached 6°F, the basement still at 40°F and the compressor running at 14 AH/day to keep it there. I readjusted one third of the way back to the previous setting and my final reading was 15 AH/day with the freezer at 4°F. I'm satisfied with that. Since my unit is 2/3 freezer and 1/3 fridge, while Sunfrost uses the reverse ratio, I consider this to be plenty enough efficient compared with their 13 AH/day smallest combo.

Access

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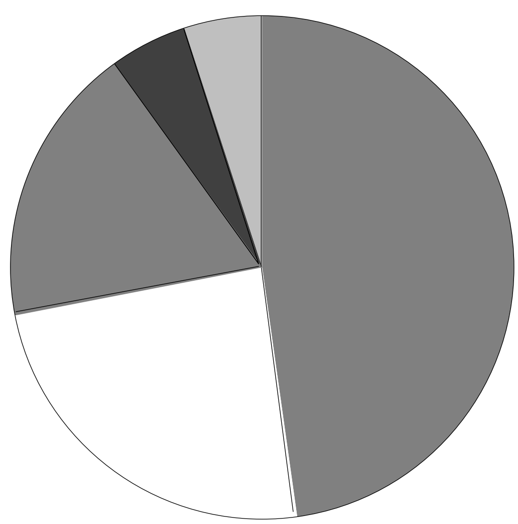
Leon Meiseler, Sun Tymes Energy Systems, RT1 Box 141A, Wheeler, WI 54772 • 715-658-1440

Refrigeration Costs

ITEM	COST	%
12 VDC Danfoss & Control	$240	48.00%
Electrician, Thermostat, & parts	$120	24.00%
Foam Insulation	$90	18.00%
Shelf brackets, clock & diode	$25	5.00%
#4 copper cables	$25	5.00%
Total	$500	



PV PANEL GLASS REPAIR

Hal Grosser KA1WBR & Roger Grosser KA1WAP

Contrary to being a total loss, it is possible to repair the broken glass of a PV panel. Here is a step by step procedure to put your damaged, broken panel back in service. The following has been successfully used to repair a Kyocera K51 panel.

CONSTRUCTION

The external parts of most panels are aluminum, tempered glass and plastic sheeting or potting compounds.

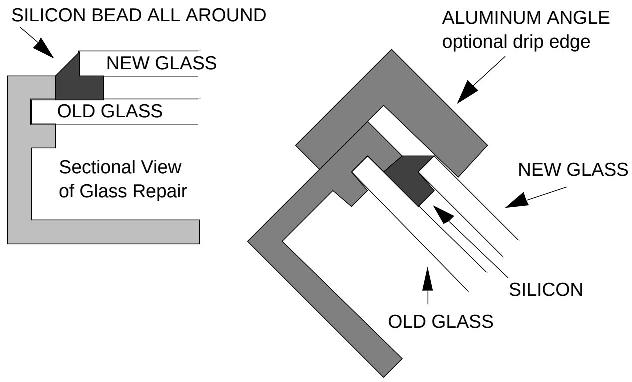
REPAIR

Don't attempt to remove and replace the shattered tempered glass. This is not generally possible because everything is laminated together at the factory.

STEP1 Get the panel out of the weather immediately. Check it for proper electrical operation. If it still produces its rated voltage & current, continue with the repair. If it doesn't, you will have something with which to experiment. Keep the panel warm and dry. It is important to keep moisture from the cells. Do not attempt to remove the glass or framework.

STEP 2 Collect the following materials:

1- a 1/16" thick sheet of ultraviolet (UV) resistant plastic (or a piece of 3 mm thick double strength glass) that will just fit within the panel's framework leaving a 1/16" space all around. Glass is $9.00.
2- a 3" or 4" paintbrush. $4.
3- 4 oz. of "Minwax Helmsman Spar Urethane" varnish (it must contain ultraviolet inhibitors). Quart costs $12.
4- a tube of 50 year "GE" clear silicon caulk. $6.



5- 2 suction cups such as from a car-top carrier. $5.
6- a plastic spoon (recycled)

STEP 3 Make sure that the panel is as dry as you can make it. Set it near a wood stove for a few days. Don't let it get too hot to touch. Lay the panel glass side up on a work bench. Carefully clean the broken surface of dirt and grime then apply one, heavy coat of urethane over the broken glass. Allow to dry for 24 hours. When it dries, you will notice that the crack valleys have rounded bottoms and edges, rather than what was sharply defined. This coating will help seal the panel from damaging moisture.

STEP 4 Lay a 1/4" bead of the silicon around the edge of the window's frame on top of the urethane sealed glass. Clean what will be the inside surface of the new glass. Pick it up from the outside surface with the suction cups. You might need someone to help. Slowly and carefully lower the new glass into place onto the silicon bead. Apply gentle pressure momentarily to slightly displace the silicon. Remove the suction cups later.

STEP 5 Smooth the displaced silicon with the plastic spoon. Make sure the area around the edge between the glass and the frame is filled with silicon. Add more if necessary. Allow to cure for at least 24 hours.

STEP 6 To install an optional drip edge on the top, cement an appropriate length of aluminum 1"x1"x1/16" angle in place with silicon. Allow the silicon to cure.

SPECIAL CONSIDERATIONS

1- Be careful of the sharp glass shards! Use gloves, safety glasses & proper clothing.

2- Clean mating surfaces prior to applying urethane or silicon. A cloth slightly dampened with a suitably safe solvent works well.

3- Be sure all will fit before applying the silicon.

4- If you install a metal drip cap on your aluminum framed panel (most are), use aluminum angle to prevent electrolysis.

5- Exercise reasonable craftsmanship and your repair should be effective as well as cosmetically appropriate.

ACCESS:

Hal or Roger Grosser at SYSTEM ELECTRIC, POB 67, Lyndon, VT 05849, (802) 626-5537

Living with a Wind Powered Generator

Dwight Swisher

We live in southwestern New Hampshire, and the weather often brings extremes of temperature and wind. Our home site is high on a hill top, open to the winds, and far enough from the utilities that commercial power has never been an option. My concern and reason for writing this is the increased interest in wind power that I see in Home Power. PVs are easy to live with. Once installed, they just sit there and work. Maybe PVs need cleaning once a year, or the snow swept off on occasion. Wind generators on the other hand, require considerable care and maintenance. My fourteen years of experience with wind generators has taught me some important lessons I would like to share with you.

Our System Now

Our electricity is now made by eight 35 Watt Mobil PV panels and a 200 Watt 12 Volt Wincharger (made by the now defunct Winco Co.). Our house runs on 110 vac made by a Trace 1512 inverter. Power storage is by fourteen 2-Volt Exide standby lead-acid cells holding 430 Ampere-hours. These cells are wired series-parallel to yield 860 Ampere-hours at 14 Volts. This system functions very well, and settles down to only 13 volts even at the greatest of loads. But things weren't always this smooth.

In The Beginning– Wind Power Alone

After a year with no power system at all, we were very happy to buy a used Wincharger. This is a small 12 Volt, 200 Watt wind powered generator. Its propeller is only 6 feet in diameter The Wincharger is direct drive, self-exciting, with no regulator and is survival rated for 100 mph. About as simple as they come. We had great expectations.

The availability of wind power is easily over–estimated. I, along with many of my friends and neighbors, thought that the apparent constant breeze at my site would mean that a wind generator would produce lots of power. The reality is that 7 to 10 mph winds are needed just to start a wind generator, and real noticeable power is not available until the wind speed reaches 12 - 14 mph.

These wind speeds are not common here during the entire summer. Fall, winter, and spring, on the other hand, are great. In the long run, what I have always read about wind power being regional is quite true. It is an unusual site that has good wind power potential. For most sites, sporadic performance will be the rule, with the best output during the seasons when the jet stream is somewhere nearby (fall, much of winter, and spring for us).

From our experience, we recommend some kind of site evaluation over the course of a year or so. This need not be high-tech, but rather, just a note on the calendar for each day's wind speed average. Use the efficiency rating for a given wind generator that is close to your desires. For example, winds of 7 - 10 mph give us 10% of rated output, while 11 - 15 mph = 30%, 15 - 20 mph = 80%, and anything above 20 mph = 100%. The rest is simple multiplication. A very simple instrument for measuring wind speed, that has given us great service, is the Dwyer Mk II wind meter (see access below). This instrument will give you a good ball park idea what to expect for output from a given wind generator.

Wind & Solar

The seasonal nature of wind power fits perfectly with the seasonal output of solar electric! I'm not a high techie. It was just obvious that the poor winds of summer are accompanied by lots of sun. So we added solar panels to our system as we could afford them. The resulting combined system is working very well for us. In the fall, solar output starts to drop off, but the winds are reliable, and our batteries get topped up for the cold months ahead. December and January are still windy enough (just somewhat less active than fall/spring) so that we have more power than we need. So much for the glory, now for the hard work.

Installation

What is written about wind generators needing to be up in the clear is absolutely correct. I tried the "roof mount" routine, and the output was poor. Also, wind generators shake allot by nature, and this literally rattled the dishes off the shelves! My Wincharger is now on a 50 foot tall tower, and its performance is 40 to 50% better. Take wind generator installation instructions as gospel. Shortcuts will cost you dearly.

High tower height means proper wiring size, etc. More importantly though, it means the machine itself is out of reach. I don't happen to mind working up there (I have the correct equipment, most importantly, a safety-belt). If working at heights is not for you, be sure there is a way to get the wind generator down easily.

Maintenance

Most any generator/alternator has brushes. These wear out. If your commutator or slip-rings are in good condition, this repair will only be necessary every few years. If you're that lucky, then your blade may need re-finishing at the same time.

Wind generator blades take an unimaginable beating. The surface is subject to "sandblasting" by dirt and ice in the air. If the blade is made of wood, when the paint fails, the blade will absorb water and go out of balance. The high rotational speeds make this intolerable. I've been able to increase the life of the blades' finish to almost three years by using a metal edge guard on the leading edge of the blade. This metal edge extends from the tip all the way in to the innermost end of the blade edge. This surface takes the most punishment, and must have metal. Copper or aluminum flashing is good for edges. Epoxy boat paint has proven the best paint. It seems tough enough to take the pounding. Wincharger blades are soft wood, and come with a varnish coating and a tip to mid-blade metal edge. This amount of protection did not last one year. If all had gone well, I would provably have seen 8 to 10 year life from the bearings on the generator shaft. As it turned out, we're on our 3rd set in 14 years. Let me explain.

Trouble

Way back when I first installed the Wincharger, I bumped the blade and cracked it. Knowing no better, I glued it and used it. Never, ever do this! All was fine for more than 2 years, until the remnants of Hurricane David passed over New York state. That day, the forecasted winds of 40 mph reached over 70 mph. The blade

broke, leaving one half on, one half off. The resulting one-armed machine tore every weld on the top of the tower loose, and broke all the wires off the generator. The machine was still screaming away when I came home that evening. I had no manual brake system at ground level at the time, and had to climb up and shut it down. That climb was one of the worst things I have ever done.

The damage was severe. Besides the obvious blade and tower damage, the bearing holes in the generator's case were hammered out of round, and the commutator had thrown its solder and had dead spots. Many friends were needed to fix all this. The lessons from this were clear. Always use first grade components on a wind generator. The forces can be many times greater than you conceive. There MUST be an easily-activated, manual shutdown for the machine. No matter what the survival rating for the wind generator is, you will not want it running during nature's extremes. More on this follows. Wind generators require management. Your judgement of weather conditions may be VERY important, and you should not rely on the weather service for wind speed predictions. If in doubt, shut it down. At least it will still be there, and ready to go, later.

Hazards

There are other hazards with wind generators that are not easily foreseen. If the wind generator will operate through the winter, then icing is about the worst. This can put the machine out of balance severely, again requiring shut-down. Usually the ice will melt when the sun comes out. Sometimes, the ice will stay for a week if it's really cold. Also, ice can stop governors and brakes from working. Springs and sliding components will fail when iced, and these are often part of the safety systems for the machine. When the wind generator was our only power source, I used to climb up and clean the ice from the prop. Now, with PV input, I can just wait for the stuff to melt.

For the most part, a wind generator installation will involve some kind of tower. Towers are lightning rods. Period. The grounding system for them is serious business. If done right, there will be a zone of protection under the tower. This grounding system must be an integral part of the whole ground system for the house and all wiring. Most all Radio Amateurs are well versed in this. If you want to learn about grounding, read up not only on lightning protection, but on electromagnetic pulse energy (induced voltage from a nearby strike). I'm not a pro. I read all I can on the subject of grounding, and the best articles I've found were in Ham Radio magazines. This might be a good subject for one of HP's readers to fill us in on...

I will tell you what's worked for us. It's simple, as I like it to be. (1) If it's negative in polarity, it's a part of the lightning ground system. Period. (2) If it's a DC circuit, there is a large knife switch that is OPEN if there is any chance of lightning. The DC lines from the wind generator to the batteries have a 1/4 inch air gap (formed by two studs at the power panel). Very near hits will create an arc across this gap, but even a direct hit (believe me, you can tell) has never caused harm.

Lightning brings with it another problem. It kills diodes! Even a near miss can kill them. Diodes are in the rectifier that changes alternator AC output to DC. They also are found in voltage regulators, etc. If your wind generator will use an alternator, be forewarned about the diode bridge rectifier. It will most likely be destroyed by lightening, perhaps regularly.

This finally drove my neighbor to abandon wind power. His Dunlite 3kw machine was on an 80 foot tall tower, and had its rectifier built into the case of the alternator. Worse yet, it was located on the "front end",so that the blade assembly had to be removed to replace the thing. He claimed that failure was at least annual. The Dunlite's blades weighed in at close to 100 lbs!

My point is this, just the blocking diode for my generator (anti-reversing diode so the generator won't motor) has failed three times, and I use the heftiest diodes I can find. If I were ever faced with a wind generator that used an alternator, I would make real sure that the diode bridge was EASY to replace.

Conclusion

Wind generators and PV panels are a great team. Together they smooth out the production of power, and all but eliminate the need for backup generators. PVs will give the most input for the dollar, are the backbone of the system, and are easy to live with. Wind power is an additional renewable power source, supplementing production, but it is less reliable, requiring maintenance and supervision. Here in the Eastern USA, many wind generators can be seen as one drives around. Most of them are NOT running, and the reason is always that there is no one to fix them. Here's hoping we can continue to promote Renewable Energy!!

Access

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Hydrogen As A Potential Fuel

Conrad Heins

In a world facing the real possibility of disastrous global warming, a fuel that does not produce carbon dioxide would appear to be a real godsend. Carbon dioxide is the ubiquitous by-product of all other combustion processes and the most important greenhouse gas responsible for that warming. Hydrogen is a potentially attractive replacement for both coal and oil as a fuel source because it produces no pollutants when it is burned. Only water is formed.

$$2\,H_2 + O_2 \text{ ---------> } 2\,H_2O$$

Although it will most likely play a role as a fuel in a renewable energy society, I believe that at the present time it is a mistake to push the use of hydrogen as a substitute for non-renewable carbon based fuels. Let me explain why.

Conservation

First and most importantly, the proposal to substitute hydrogen for other fuels is addressing the problem from the wrong end. We should be concerned far more with reducing the need for fuel, through conservation and improved energy efficiency, than with replacing a "dirty" fuel with a "clean" one. In the United States we use about twice as much energy as the Germans or Scandinavians to accomplish the same tasks, whether they be heating their homes or driving to work. We need to focus not on the supply-side but on the demand side of the energy equation.

Application

A second, related point is that by addressing the problem in terms of supply we tend to ignore how the energy is being used, We fail to ask the critical question, "Is this particular kind of energy the best answer for this particular application?" Only when this question is posed are we able to to make judicious choices, especially if we want to take into account the second law of thermodynamics efficiency considerations, which deal with energy quality as well as energy quantity, or environmental impacts.

Reaction

Third, hydrogen is a far more reactive chemical than any of the materials that are currently used as fuels. I am not talking about flammability or explosiveness, but rather hydrogen's ability to undergo chemical reactions with other compounds. It is a good reducing agent; it adds to double bonds, causing embrittlement of plastics and elastomers; and, because it is such a tiny molecule, hydrogen can even work its way between the atoms of metals such as steel, causing hardening and embrittlement.

Unrenewable

Fourth, hydrogen is not made from a renewable energy source. Virtually all of it is produced from natural gas, methane, by an endergonic reforming process that uses steam.

$$CH_4 + 2\,H_2O \text{-------------> } CO_2 + 4\,H_2$$

It might be argued that because part of it comes from water we are obtaining the hydrogen, at least partly, from a renewable resource. However, the energy captured in the hydrogen will always be less than the energy in the methane plus the energy required to drive the reaction. And carbon dioxide is still produced; as much, in fact, as would be formed if the methane were burned as a fuel in the first place! Why waste energy to produce an energy storage material that is far more difficult to store and handle than the fuel it is made from, especially when the starting fuel is the cleanest burning of any of today's primary energy sources.

It must be emphasized that hydrogen is made from natural gas because this is the least expensive way to make it--considerably less expensive, for example, than of using electrolysis of water using electricity at off-peak rates. It is unrealistic to assume that, at least for the near term, hydrogen would be made in any quantity from anything but methane. We are left with the likelihood that the "hydrogen economy", like today's "hydrocarbon economy", would be based on a non-renewable resource.

Solar Hydrogen

Of course, it is possible to break apart water and obtain hydrogen in other ways. The formation of hydrogen and oxygen from water using electricity is the one that is most often touted. If the electricity is provided by PV panels, we are talking about using a renewable energy resource, sunlight, to provide hydrogen in a non-polluting way. Such a proposal, when first heard, sounds attractive. However, a little further examination indicates that is not a good answer.

The biggest problem is the prodigious amount of electrical energy that would be required to replace even a portion of the hydrocarbon fuels we now use. Wilson Clark, in his classic book, Energy For Survival, makes his point very clear.

"The amounts of hydrogen that would be required in a hydrogen economy are enormous. For instance, according to Dr. Gregory, to produce enough hydrogen to fully substitute for the natural gas produced in the United States at the present time [1974] --i.e., 70 trillion cubic feet of hydrogen-- would require more than 1 million megawatts of electric power to produce. Total electric generating capacity in the United States is only 360,000 megawatts. To meet the projected hydrogen requirements for natural gas alone would call for a fourfold increase in generating capacity, which would mean building 1,000 additional 1,000-megawatt power stations! This does not provide for increased electric power demand for other purposes, nor does it take into account the generation of hydrogen for transport fuel or as an additive in chemical and industrial processes."

By way of comparison, world production of photovoltaic generating capacity was about 50 megawatts (peak sun) last year. Even if this capacity were to be increased a 100-fold and all of it used to produce hydrogen, we would still be making a fraction of 1% of what would be needed to replace the natural gas consumed in the U.S. In addition...

Storage

Why use electricity, the most versatile form of energy available, to produce a material that is not easily stored (the boiling point of hydrogen is -435° F., about 25° F. above absolute zero) or handled and that will probably be burned to produce mechanical energy in a process that will be less than 30% efficient...When the electricity might be used directly?

If energy storage is needed, why do it through such a difficult-to-store material for which large scale storage technologies do not even exist, When electricity can be stored in batteries, flywheels or pumped storage systems far more effectively.

Efficiency

If it is to be used for transportation, why select a process that will operate at no more than 30% efficiency (an internal combustion engine) when an electric motor can be used that is at least 75% efficient? And why select a fuel that is so difficult to deal with in a mobile situation? (Wilson Clark, one of the early proponents of hydrogen fuel, includes a good discussion of the hydrogen powered automobile in ENERGY FOR SURVIVAL. He points out that a Dewar flask type container for liquid hydrogen that would that would hold the energy equivalent of 15 gallons of gasoline would have to be about 37 gallons in size and would cost (1974 prices) about $1,800. The use of metals, such as magnesium, to store hydrogen as a metal hydride would require an even larger volume).

Why Photovoltaics

Finally, why photovoltaics? As pointed out earlier, photovoltaics is not a good choice for generating vast amounts of electricity. It is much more suitable for smaller scale applications where grid power is not available. Although it will probably be used to generate utility power as well, utilities have never considered using it in any other capacity than for peaking power. In addition, these systems presently produce electricity at a cost of from $.25 to $.75 per kilowatt hour (20 year life cycle cost). Even were the cost to be cut in half, which is what we expect to happen during the next decade, we are talking about a much more expensive kind of electricity than could be produced by other renewable sources, such as the LUZ concentrating solar thermal facility that is presently supplying peaking power to the Los Angeles basin at about $.08 per kilowatt hour.

If these questions are answered primarily by, "because photovoltaics is renewable and non-polluting, and the burning of hydrogen produces no pollutants", I suggest that a much more thorough analysis of the situation needs to be carried out.

Access

Dr. Conrad Heins teaches a course in renewable energy, including photovoltaics, at Jordan College, 155 Seven Mile Rd, Comstock Park, MI 49321

Above: Ken Olson visiting health centers on the Colombian coast. Here he tows a dug-out canoe through a creek in the province of Choco heading towards the town of Pie de Pato. Photo by Bernardo Ganter.

Solarizing the Cold Chain

Walter Gallacher

The Pan American Health Organization is committed to eradicating polio in South America before the turn of the century. Solar energy is playing a major role in this campaign. Here is a story of how three Colorado solar educators are helping introduce photovoltaic technology to improve rural health care. PV powered refrigeration is the key.

Polio still kills

Polio once took the lives of hundreds of American children each year and left thousands crippled in its wake. That was until a vaccine was discovered in 1957. Today polio is no longer a threat in the United States; but for our neighbors in Central and South America polio is still one of the leading causes of death and deformity in young children.

The problem is not a lack of vaccine. Polio vaccine is plentiful and relatively inexpensive. The problem is a lack of refrigeration. In order to be effective, the vaccine must be kept cold, 0 to 8 degrees Centigrade (32° to 46°F.). Reliable refrigeration is virtually non-existent in rural areas of Central and South America. Kerosene and propane powered refrigeration is commonly used, but fuel supplies are unreliable. When there is fuel it is often contaminated.

During the 1960s and 70s, the absence of reliable refrigeration prevented the Pan American Health Organization from effectively halting the spread of the disease in Central and South America. But with the refinement of photovoltaic technology in the 1980s, experts at Pan American Health began to look to solar energy for the answer to their problem. They realized a network of solar powered refrigerators would allow them to move vaccine from the point of manufacture to major storage points, then to regional storage facilities and ultimately to inoculation centers.

The Solar Cold Chain Project

The Solar Cold Chain Project as it is referred to, had real possibilities if adequate installation sites could be found and people trained to maintain the equipment and teach others. Peter Carrasco, technical director of the immunization program at the Pan American Health Organization, began recruiting experts in solar refrigeration. He attended a two-week summer workshop in photovoltaics at Colorado Mountain College conducted by Steve McCarney, John Weiss, and Ken Olson. All three had earned national reputations for their knowledge of photovoltaics and their

ability to train others.

Carrasco explained the Cold Chain and asked them if they were interested in helping. The answer was a resounding yes. "We had always wanted to get this technology to the people who needed it the most," says McCarney. "This was a perfect opportunity."

Over the next two years the project evolved into a three stage plan that allowed each of the solar experts to direct a phase of the project. It was decided that Steve McCarney would take phase one, designing and field testing the training materials. Ken Olson would direct phase two, technician training, site surveys, and the final draft of the training manuals. John Weiss would handle the third stage — on-site installation and ongoing training of local technicians.

On November 12, 1988, McCarney left Colorado on phase one—an eight month journey with stops in Colombia, Chile, Bolivia, Peru, Guyana, Trinidad, Jamaica, St. Vincent, the Grenadines and Thailand. The first stop was the University of Valle in Cali, Colombia. The Pan American Health Organization has established a vaccine refrigeration testing lab on the campus. It is in this lab that solar refrigeration units are subjected to the extreme conditions that can be found in the jungles and deserts of Central and South America.

From Colombia, McCarney headed for Chile. In Chile, he field tested one of the "how-to" manuals he had drafted on photovoltaic installation for refrigeration technicians. From Chile, he traveled to the rainforests of Bolivia to set up equipment that would begin measuring the amount of sunlight the rainforest receives annually. The Bolivian rainforest data will eventually be used to design and build photovoltaics that maximize the use of the limited sunlight in that area. From Bolivia, McCarney flew to Trinidad, Jamaica, and Guyana to teach refrigeration experts how to adapt to PV power.

There was time along the way to visit some friends in Peru and to deliver a very special personal gift. The summer before his trip he had met two weavers at a mountain crafts fair in his home town of Carbondale. The weavers were from Tequile, a small island in the middle of Lake Titicaca. The lake is high in the Andes Mountains and covers 3200 square miles.

"Tequile is almost like a desert island in the middle of the lake," says McCarney. "The islanders have never figured out an efficient way to pump the water out of the lake." McCarney's gift was a solar powered pump.

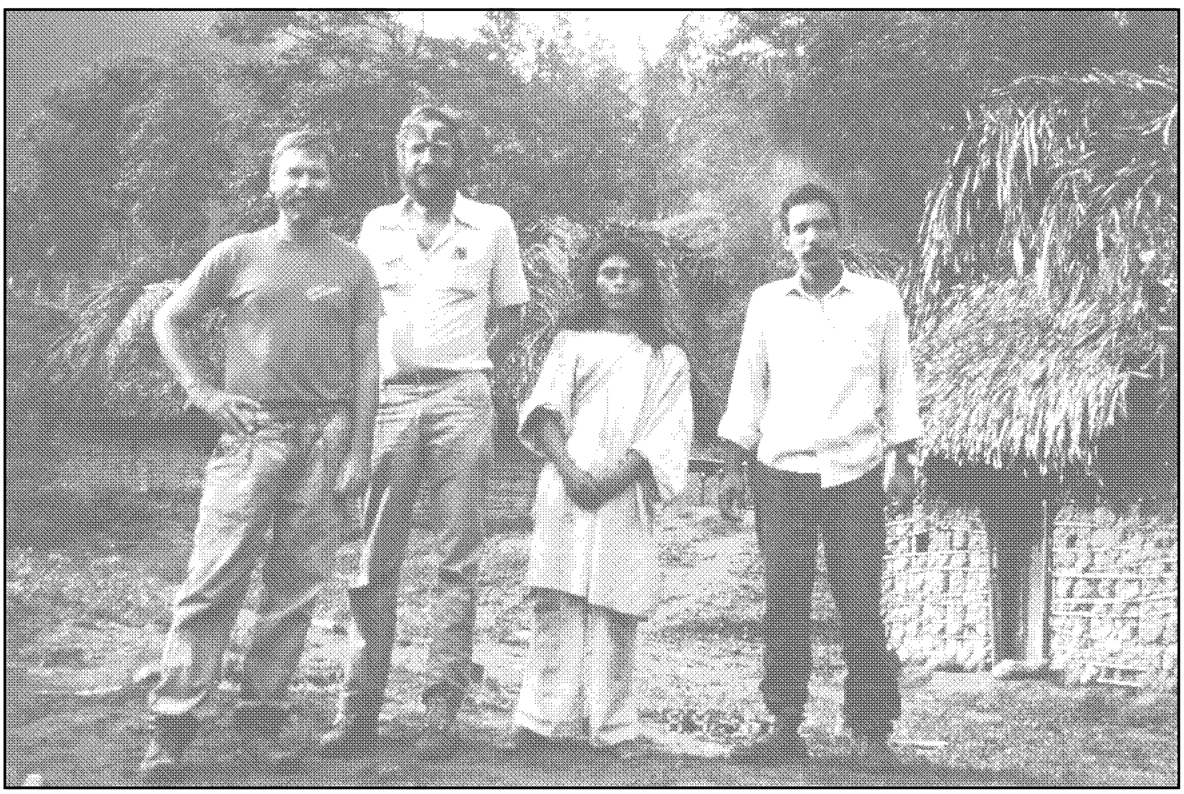
The next stop was Thailand's Chon Ken University where McCarney consulted with Thai officials and members of a Canadian research team. The research team was evaluating Thailand's economic development, and wanted the solar expert's advice on the role solar energy could play in the development of Thailand's agricultural industry.

McCarney returned home that summer with just enough time to brief his partners and help Ken Olson prepare for his trip. Peter Carrasco and Olson had worked out a year-long itinerary that would have Olson trekking across Columbia, Peru, Bolivia, Equador, and Panama teaching local technicians how to select appropriate sites and order materials for a solar installation. Olson spent six weeks in Cali, Columbia teaching technicians from Columbia, Peru, Bolivia, Guatamala, Panama, and Chile in solar refrigeration using the manuals that McCarney had developed during his stay.

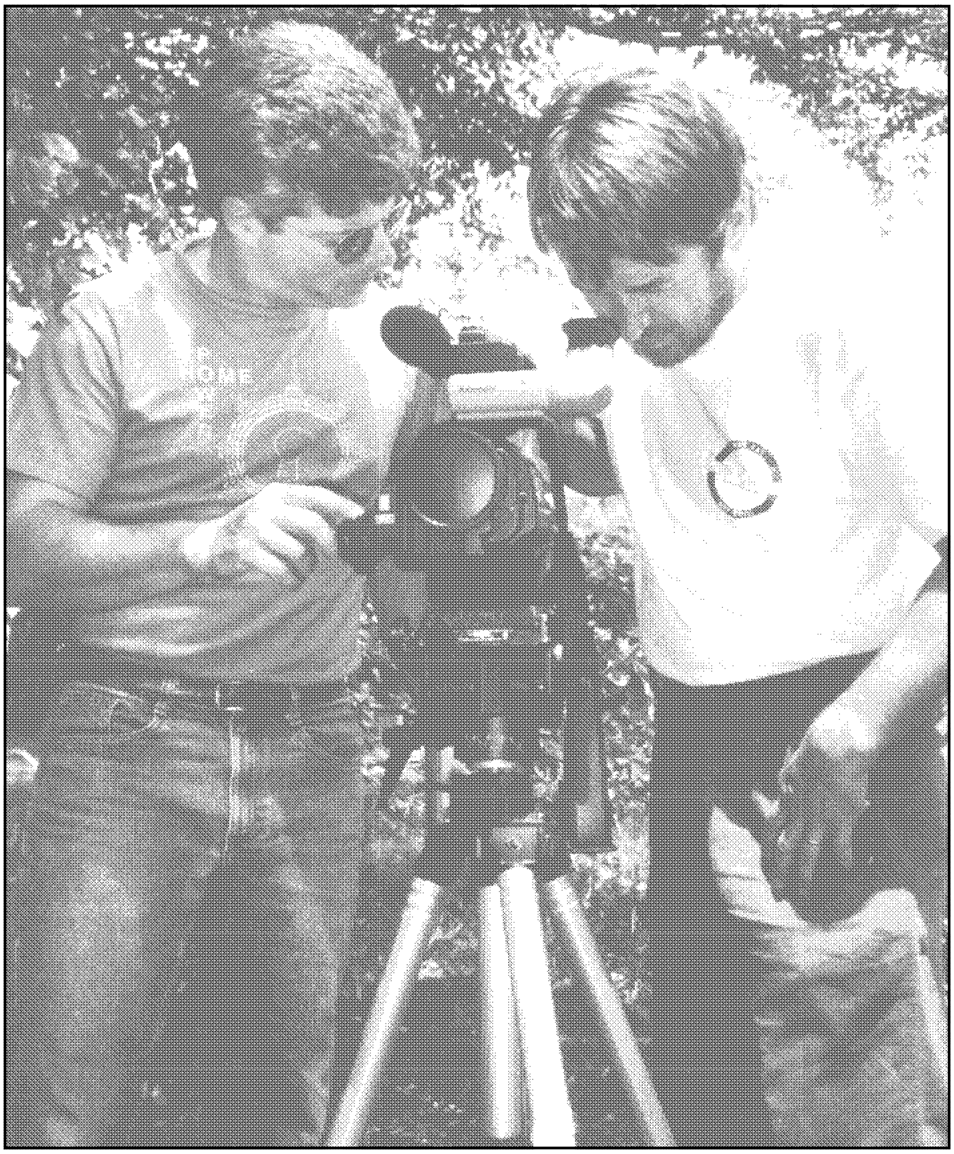
From Cali, Olson trekked to the Sierra Nevada de Santa Marta mountains in northern Colombia. It took three weeks to visit four of the twenty sites government officials had chosen for solar installations.

"Travel was slow," says Olson. "Occasionally we went by jeep, but most of the time we made it on foot or by mule. Traveling through this country was like turning back the pages of history two hundred years," says Olson. "I met Indians that I never knew existed and from the looks on their faces they had never seen anybody like me." Blond haired anglos are rarely seen in the jungles of South America.

Some of the most memorable moments of Olson's trip were spent with the Kogi Indians. He tells the story of a small village that had been burned out and taken over by marijuana growers. With the help of the Columbian government the Indians were able to reclaim and rebuild their village. They are especially proud of their school.



Above: From left to right, Ken Olson, Carlos Dierolf (an engineer for the University of Valle), José Miguel (the Kogi Indian guide), and Bolo Bolo (the hispanic guide).



Above: Johnny Weiss and Juan Livingstone direct a video production documenting PV powered health care in South America.
Photo by Solar Technology Institute of Colorado.

"The kids are being taught three languages and they are all Indian. No English, no French, no Spanish," says Olson.

Olson had another experience he will never forget while he climbed through the Sierra Nevada de Santa Marta mountains. He and three team members had just jeeped out of a village when two armed guerillas stopped them. Olson's blond hair and U.S. passport made him the focus of attention. The guerillas wanted to know if he was related to Bruce Olson, a U.S. sociologist who had been recently released after being held captive for nine months by their group. After some very tense moments Olson and his three companions convinced the two men that Ken was not even distantly related to their former hostage.

"At that point they seemed to relax a bit," says Olson. "They asked us if we had any questions. We found out that their objective is to free Colombia of foreign oil investments. They blow up pipelines. They fund their activities through kidnapping and extortion." Olson still cringes when he thinks about where he might be today if it hadn't been for his fast talking companions.

From Colombia Olson traveled to the jungles of Bolivia where he installed three solar gauges like the one McCarney had installed a year before. From there it was back to Colombia, but this time to the jungles along the country's Pacific coast. All the communities in this region are built along the river. "The only way to get around is in hollowed-out logs," says Olson. The Colombian government had designated eight communities as sites for solar refrigerators. Olson's job was to teach his companions how to determine if a site is appropriate for a solar installation, and then how to prepare the site and order materials.

The project on Columbia's Pacific coast went smoothly, but the same could not be said for the next leg of Olson's trip, Peru. Olson and his party quickly discovered that everything they had heard about Peru's instability was true. The mountains and inland jungles are controlled by the Indians and guerillas. One of the technicians was held up four times by different groups of Indians and guerillas. Within a few weeks Peru's project was postponed. Olson utilized the time he would have spent on Peru's cold chain to make a trip to the states and work on his report to Pan American Health. In his report, "The Photovoltaic Volunteer Transfer Program," Olson outlined a plan for developing the skills and experience of native people so they could utilize photovoltaic technology without prolonged dependence on industrialized nations.

The last stop on Olson's journey was Panama. The chaos of Peru was a contrast to the smooth efficiency of Panama. Olson revised his report during his visit and presented it to Panama's government health officials. The report was well received and plans are being made for a return visit.

While Olson was wrapping up in Panama, John Weiss was packing for a trip to the University of Valle in Cali, Colombia where he would spend a month in orientation preparing for the installation phase of the project. Traveling with Weiss was a former student, Juan Livingstone. Livingstone had grown up in Chile and emigrated to the United States when he was eighteen. He spent twelve years in California before moving to Colorado to study solar technology.

Weiss and Livingstone flew to Cali in the summer of 1990 to spend a month at the University of Valle studying refrigeration systems used in South America and learning more about the politics of this vast continent. "Each of the countries involved in this project are at different stages of the process," says Weiss. "Some are in the planning stage while others are ready for installation. Pan American Health can only advise and recommend, it is up to the ministry of health in each country to decide what approach to take." For years, Weiss, Olson and McCarney have taught students how to adapt solar energy to suit individual needs. "Solar energy, like any appropriate technology for the developing world, has to be done carefully and in the context of that particular culture," says Weiss. "If that perspective isn't maintained the Cold Chain won't work because the solar systems will not be sustainable."

In September, Livingstone spent two weeks in the Dominican Republic assessing that country's needs and establishing contacts with officials at the Ministry of Health. Weiss left January 7th for a month in Honduras where he will visit potential installation sites, inspect solar equipment and work with Honduran health officials on the refinement of their Cold Chain plan. Plans are also being made to assist El Salvador and Nicaragua and follow-up visits are scheduled for Guatamala, Peru, Panama, Bolivia and Colombia.

Slowly and deliberately, war is being waged against polio and other communicable diseases in South and Central America. "Solarizing the Cold Chain is a huge project that can seem overwhelming at times," says Weiss "but I think Pan American Health can improve rural health care with PV powered vaccine refrigerators. We feel that this is the most rewarding work we have done in solar energy."

Access

Ken Olson and Johnny Weiss have established the Solar Technology Institute of Colorado, (see Happenings in this issue). They will be offering the following summer workshops: Photovoltaic Design and Installation, Solar for the Developing World, and Solar Technology for Rural Health Care. For details, contact Ken or Johnny at P.O Box 1115, Carbondale CO. 81623-1115 or phone (303) 963-0715.

Steve McCarney is now Caribbean Regional Manager for Photocomm Inc.. He is based in San Juan, Puerto Rico.

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Having It Both Ways

Michael Potts

I live in a small town on the North Coast of California. We joke about being on the edge of the continent, but power lines run down Main Street and I get most of my power the easy way: from the grid. We get some weather up here, and it takes the power out regularly a dozen times a year, sometimes for a day at a time, and so I put quite a bit of thought into surviving the times we are on our own - gas cooktop, passive solar and wood heat, gravity fed water, solar hot water. Kerosene lighting is romantic, but it is inconvenient to scurry around in the dark to find the fragile lamp and the elusive match. There must be a better way.

I designed my house when 12-volt lighting meant automotive lighting, and my power supply was a car battery and a trickle charger plugged into the wall. Fortunately, I had plenty of wire, and ran a lot of duplicate circuits, thinking I might like to use alternative energy more extensively down the road; here I am, down the road, and I am glad I buried all that copper in the walls! Because the times have changed, a kilowatt off the grid costs five times what it did and promises to go higher, and I couldn't live without the reliability of the 12-volt system. The first low voltage light bulb to go on was a light above the bed. When the power failed, it gave off enough light for me to find flashlight or lamp and match. But I soon discovered that the light was perfect for reading - why not use it all the time? Why not add a 12-volt digital clock, so the time would always be correct, even after a power failure? There's an uncanny correspondence between high winds and power outages here on the edge, and the anemometer - the device that tells how fast the wind is blowing - always went off about the time the winds got really interesting: why not put it on the low voltage system? Easy - and I got rid of a little transformer that was converting 110v AC into 12v DC with that little extra inefficiency we've grown to love.

The uses of low-voltage power, and the justifications for using it, are many and multiplying. Energy self-sufficiency is, perhaps, the best. At the most trivial, it just feels good to have a hand on generating my own power. In my work as a writer and computer consultant, it also saves me money: time when the lines are down but I can work anyway, because my computers run on the 12-volt system, and work saved that I used to lose when the grid went down. I enjoy the reliability of a small, centralized system. I confess to a small twinge of superiority when the lights all around me go dark, but my house remains workable.

The Nuts and Bolts

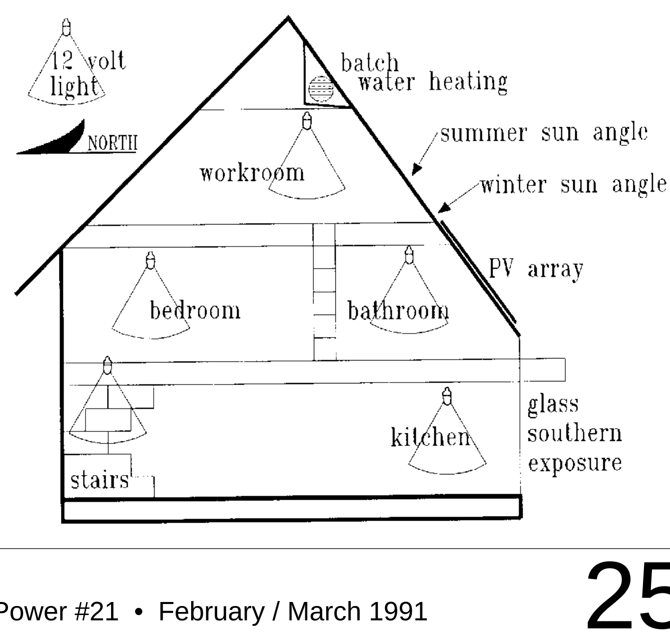
Designing low-voltage circuits into a house still on the drawing board costs very little, and will add only slightly to the electrician's bill. You must try to think of the places where alternative energy will be of use, and provide the branch circuits. The `All Electric Home' of the fifties uses electricity in profligate ways, where a `remote home' makes the most of what is available, and so the alternative system should provide just enough. A well integrated system will allow a degree of swapping back and forth between AC and DC circuits just by changing fixtures and connections at source and destination. When the wiring is all done, it should look to you, your electrician, and the building inspector, like an over-wired house. You should accept from the beginning that, no matter how carefully you plan, your needs or the technologies will change. Retrofitting an existing house - adding a 12-volt system to a house already wired for conventional power - is as complicated as rewiring a house, and could involve ripping out walls and all manner of unpleasantness. It simply may not be worth it. Plan a limited application, or incorporate it into any renovation plans.

The power required to perform a function is comparable, from 110v AC to 12v DC. It will still take wires to power a low-voltage lamp, and the hardware at both ends is nearly the same. Buying more of the same wire, boxes, and connectors offers economies of scale, and you (or your electrician) already know how to deal with the running of it. Part of the planning phase must go to researching the availability and best source of alternative devices. Low voltage lighting is well developed, but there are fewer appliances. If power outages are a major problem, you should plan your AC system to allow branches to be cut over from the grid to an inverter, so essential services (like microwaves and blenders) can still operate.

A good place to learn what can be accomplished and how much power you need is in these pages. Other good sources come from Real Goods in Ukiah - their Alternative Energy Sourcebook and Remote Home Power Kits Manual provide an encyclopedic listing of low-voltage devices and the whys and hows of installing alternative energy systems. Whatever you do, you must remember to work safely with low voltage systems; although they are inherently safer (you could not electrocute yourself as conveniently) there is still plenty of power to manage.

The Elements of a System

An alternative energy system consists of a power source (or several sources), storage device, transmission paths, and the tools and fixtures that turn power into something useful. To put together a useful system, you must consider the whole system, always



keeping the goal in mind. For me, the goal was enough light to get around with and an uninterruptable power supply for my computers. I made a schematic of my house, identified the fixtures and their power requirements, and used (naturally) a spreadsheet program to make revising the calculations simpler. I specified a generous system to allow myself room to add to the system, and this is what I came up with:

System Requirements

Power Uses	Wattage	Hrs./day	Full Watt-hrs.	Small Watt-hrs.
Lighting	50	3	150	150
Instrumentation	25	24	600	600
Computers	300	6	1800	
Tools	50	2	100	100
Total Watt-hours required			2650	850
Amp-hrs. required in a 12 VDC system			221	71
PV panels required (5 hrs. sun daily)			15	5

Fifteen panels might be too many for the space allotted, and so I elected to run the computers from a system attached to the grid through a charger, and the lights, tools, and instruments from a second, `honest' system. (I had not planned for the computers, and so this simplified the retrofit wiring.)

Storage capacity has to bridge the gap between the time the source is lost and comes back on line. On the computer system, the source is the grid, and I wanted at least two hours to complete my work in an orderly manner. Storage required: 2 100- amp-hour gel-cell batteries. For the lights and instrumentation, where the source is the sun, I needed to be able to go about a week with negligible charging - the longest a serious stormy patch lasts in these parts. Again, about 200 Amp-hours of storage should tide me over.

If I take this much trouble to gather my own power, I should be frugal in using it, and that guided my selection of wiring and fixtures. The larger the wire, the lower the transmission loss, and so I wired with 12/2WG wire - 12 gauge, 2 conductor plus ground, the electrician's standard household wire. I like the intensity and color temperature of halogen lighting, and so that was my choice for task lighting. For wider area lighting, the high efficiency PL fluorescent technology is the only rational choice - it uses a quarter the energy of its incandescent equivalent, and lasts ten 10 times as long. (While I'm being frugal, I might apply the same logic to my 110v AC lighting and save a bundle - see sidebar at the end of this article.)

Wiring the 12 volt fixtures is very straightforward: take the same precautions you would with 110 volt wiring with respect to overcurrent protection with a fuse box or distribution center, use 12v DC switches, conventional wire-nuts to make splices, make all splices in boxes, and use clamps to protect wires from sharp metal edges if you are using metal splice boxes. `Cigarette lighter' type plugs, are ungrounded, and are frowned upon by the authorities. Since 12 volt DC is so benign, you may be tempted (knowing you have fused the circuit conservatively and can be careful to avoid shorting the wires) to work the system `hot' and get immediate confirmation when you've got something wired in: it lights up! This is a bad and reckless habit; some humans experience burns and worse even with low voltage power, so work it cold - pull the fuses. Observe the polarity with more care than with conventional AC wiring, because you run the risk of frying delicate instrumentation if you get it backwards. If in doubt, use a multimeter to establish polarity, and use red electricians tape liberally to mark the positive side.

Is It Worth It?

There is no doubt that it costs more to run an alternative system - in the short run, and with nothing else considered. After all, you're building the generation capacity that the utility company provides as well as the consumer end of things. The utilities hasten to tell us about economies of scale, but there is reason to suspect that subsidies play a big part in the real equation, and there are many hidden costs to fossil-fuel and nuclear power generation as well. But I was curious to know just how much this thing would cost.

Projected Electricity Rates

California North Coast- in dollars per kiloWatt-hour

Year	Conservative Projection $ / kWh	Yearly % Increase	Realistic Projection $ / kWh	Yearly % Increase
1986*	**$0.08810**		**$0.08810**	
1987*	**$0.08812**	**0.0%**	**$0.08812**	**0.0%**
1988*	**$0.09940**	**12.8%**	**$0.09940**	**12.8%**
1989*	**$0.10910**	**9.8%**	**$0.10910**	**9.8%**
1990*	**$0.11880**	**8.9%**	**$0.11880**	**8.9%**
1991*	**$0.13400**	**12.8%**	**$0.13400**	**12.8%**
1992	$0.14882	11.1%	$0.15142	13.0%
1993	$0.16528	11.1%	$0.17110	13.0%
1994	$0.18357	11.1%	$0.19335	13.0%
1995	$0.20387	11.1%	$0.21848	13.0%
1996	$0.22642	11.1%	$0.24689	13.0%
1997	$0.25147	11.1%	$0.27898	13.0%
1998	$0.27928	11.1%	$0.31525	13.0%
1999	$0.31017	11.1%	$0.35623	13.0%
2000	$0.34448	11.1%	$0.40254	13.0%
2001	$0.38259	11.1%	$0.45487	13.0%
2002	$0.42490	11.1%	$0.51401	13.0%
2003	$0.47190	11.1%	$0.58083	13.0%
2004	$0.52410	11.1%	$0.65633	13.0%
2005	$0.58207	11.1%	$0.74166	13.0%
2006	$0.64646	11.1%	$0.83807	13.0%
2007	$0.71796	11.1%	$0.94702	13.0%
2008	$0.79738	11.1%	$1.07013	13.0%
2009	$0.88558	11.1%	$1.20925	13.0%
2010	$0.98354	11.1%	$1.36645	13.0%
2011	$1.09233	11.1%	$1.54409	13.0%

***ACTUAL DATA**

Back to the spreadsheet.

If I assume that power costs will continue to escalate at about the current rate, I predict that I'll see the rates on the spreadsheet on future electric bills. Please note: all projections of cost are strictly ball park. These estimates, while better than using an entrails oracle to see the future, are just educated guesses.

Using the realistic model as a basis for analysis, costs will double about every six years from the present rate of just over 13¢ a kilowatt-hour, crossing the 30¢/kWh line as early as 1998.

To build a system to completely satisfy my alternative needs - so I would be able to survive if the utility company folded its tent and stole away into darkness - would cost about $9000, and would perform as follows:

A Generous PV System's Production

Ampere-hours per day	225
Ampere-hours per year	82,181
kiloWatt-hours per year	986
System Cost	$9,000
System Life in years	30
Power Cost in $/kWh	$0.3042

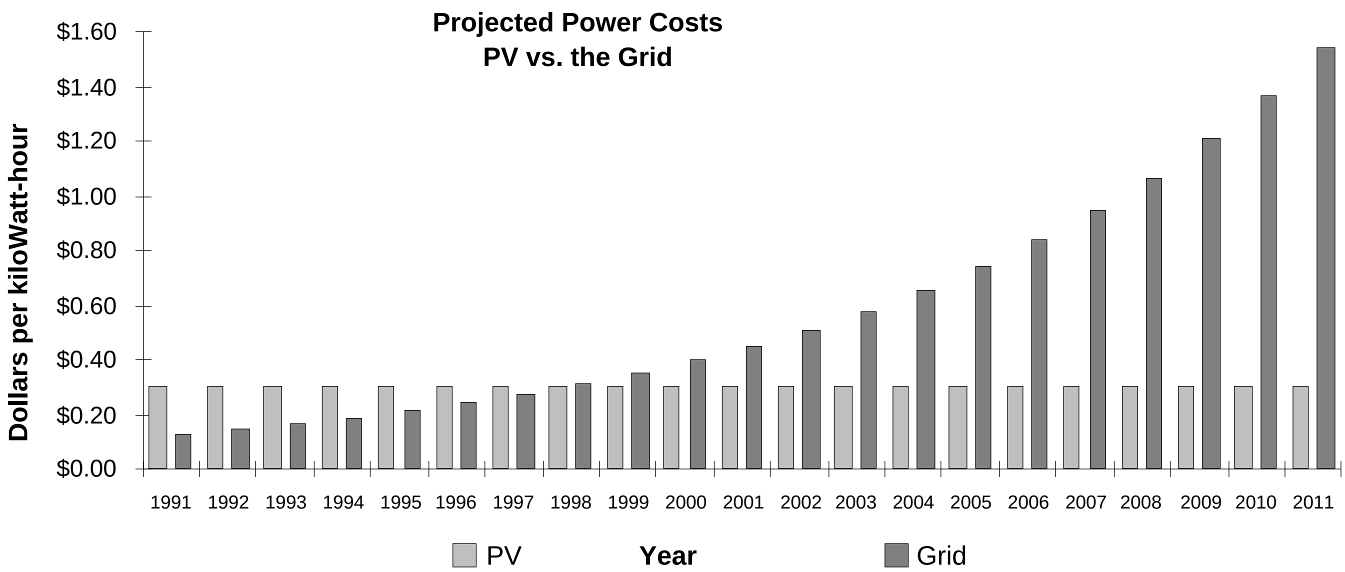
In other words, it would be competitive in 1998, assuming a 30 year life. Using the full cost model, where an extra dime is added to each kilowatt-hour to mitigate the hidden costs, subsidies, and do forth, including the $83 billion a year attributed to the health effects of fossil fuel power production, the crossover point is as early as 1994. But what about breakeven?

Using the "realistic projection" model, just over half way through the expected design life of my system, I start to turn a profit. By the end of its useful life, I had made a bundle. When I showed this

Breakeven analysis – annual costs

986 kWh yearly • Initial Cost - $9,000.

Year	$ / kWh PV	$ / kWh Grid	Yearly Cost PV	Yearly Cost Grid	Amortized Cost (Profit)
1991	$0.30	$0.13	$9,000	$132	$8,868
1992	$0.30	$0.15	$0	$149	$8,719
1993	$0.30	$0.17	$0	$169	$8,550
1994	$0.30	$0.19	$0	$191	$8,359
1995	$0.30	$0.22	$0	$215	$8,144
1996	$0.30	$0.25	$0	$243	$7,900
1997	$0.30	$0.28	$0	$275	$7,625
1998	$0.30	$0.32	$0	$311	$7,314
1999	$0.30	$0.36	$0	$351	$6,963
2000	$0.30	$0.40	$0	$397	$6,566
2001	$0.30	$0.45	$0	$449	$6,118
2002	$0.30	$0.51	$0	$507	$5,611
2003	$0.30	$0.58	$0	$573	$5,038
2004	$0.30	$0.66	$0	$647	$4,391
2005	$0.30	$0.74	$0	$731	$3,660
2006	$0.30	$0.84	$0	$826	$2,834
2007	$0.30	$0.95	$0	$934	$1,900
2008	$0.30	$1.07	$0	$1,055	$845
2009	$0.30	$1.21	$0	$1,192	($348)
2010	$0.30	$1.37	$0	$1,347	($1,695)
2011	$0.30	$1.54	$0	$1,522	($3,217)



windfall to my accountant, he advised me to buy my power from the utility, put the $9,000 in CDs, and really make out 30 years from now. I told him he missed the point.

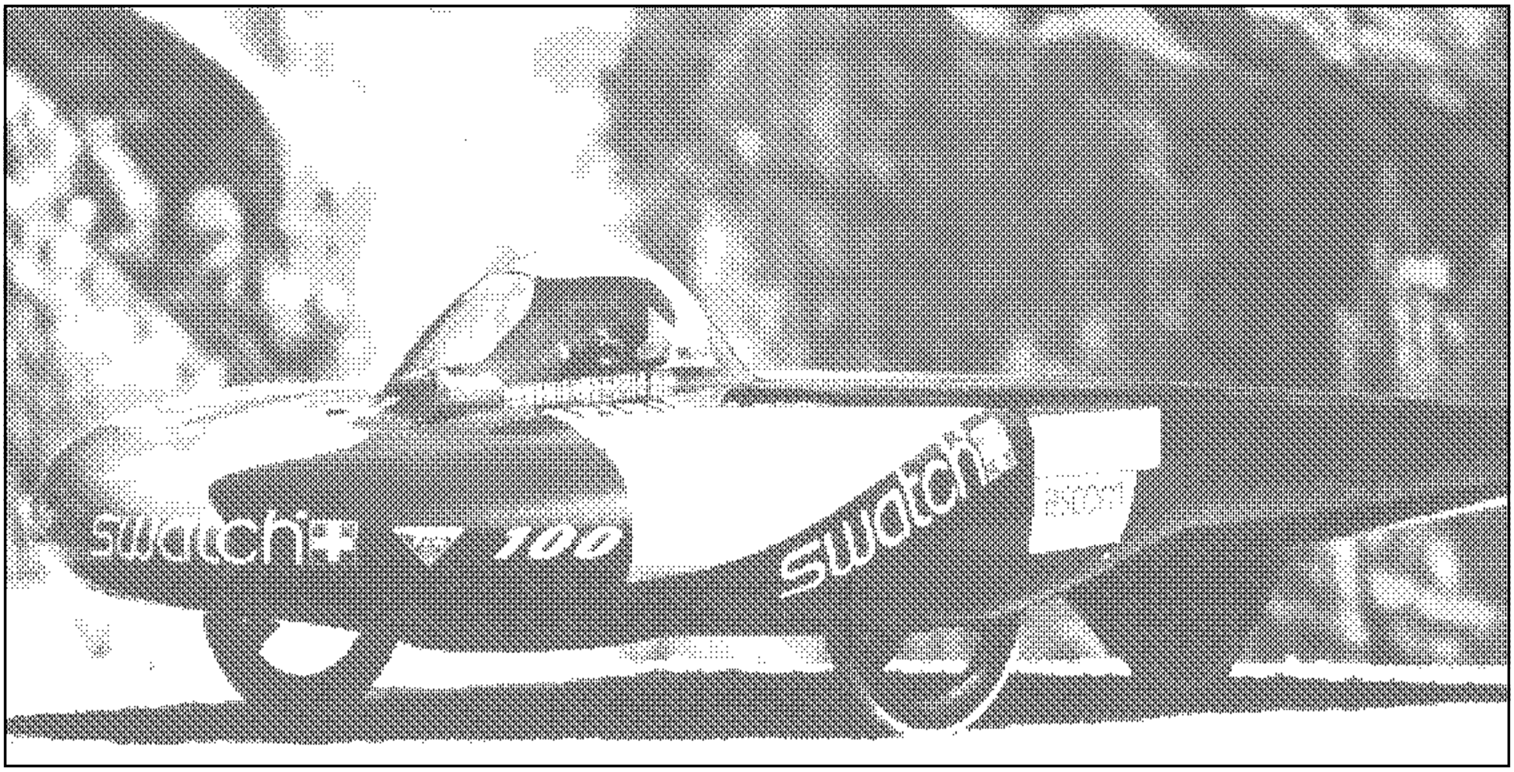
What is the Point?

Enough sunlight falls on the exposed southern face of my house to provide for modest electric and hot water needs; it would take only a minor realignment of my priorities for me to live within my own capacity. The same is true for my neighbors almost everywhere in rural and suburban America; elsewhere around the globe, what I would consider a sufficiency would be thought a surfeit. The energy equation has had some its key terms shifted - the real cost of a barrel of crude used to generate the bulk of America's energy may be $30 (today's market price for West Texas) or $80 (Carl Sagan's guestimate) or $200 - $500 (GreenPeace's pessimistic assessment) - and the trend is not likely to reverse. Energy costs will rise, and the only argument is about whether it will be a linear, a geometric, or an exponential curve. My assumptions have taken the middle ground. My favorite columns in the Breakeven table are the second and fourth, which show that I have locked in a reasonable rate for my power, and that my capital expenditures are negligible after the initial outlay: a healthy economic profile, particularly when compared with the uncertainties of the public energy picture. There are undoubtedly hidden horrors in the photovoltaic closet - what chemicals despoil what streams near the factories where silicon wafers are fabricated? How much power does it take to make a silicon wafer? - And I hope I will find the answers to these concerns.

The point, simply, is that we need not uproot carbon compounds it took nature millennia to get buried just to enjoy ample power. A grass roots grid, community PV arrays and distribution channels, and a sharing of technology, can back us out of the ugly corner we seem painted into. Since the myth of cheap power has evaporated, those of us who are mainstreaming our power from the grid must reassume responsibility for our energy needs.

Access

Michael Potts, C/O Real Goods Trading Corp., 966 Mazzoni St., Ukiah, CA 95482 • 707-964-1844.



Above: The winner of the 2nd World Solar Challenge. 1,800 miles powered by sunshine!

Swatch "Spirit" Powers to Victory in World Solar Challenge

The Swatch-sponsored "Spirit of Biel-Benne II" cruised to a stunning solar-powered victory Friday, November 16 in the 2nd World Solar Challenge in Adelaide, South Australia. The "Spirit" reached the finish line in 6 days after covering over 1800 miles in approximately 47.5 hours. Averaging 36 to 48 mph, the "Spirit" took the lead three hours outside of Darwin in the Northern Territory, the starting point of this incredible race of solar technology.

Highlights

Highlights of the Swatch/Biel performance include an incomparable top speed of 54 mph during the race's third stage on Tuesday, November 13. On this day, the four "Spirit" drivers covered 378 miles averaging 45 mph for the day. By the end of the fifth day, the "Spirit of Biel-Bienne II" had increased the lead over its nearest rivals from Japan and the United States to 210 miles placing them in a virtually untouchable position for the 144 mile homestretch.

The Swatch/Biel "Spirit of Biel-Bienne II" totally outclassed an impressive field of 40 entrants including three General Motors-sponsored vehicles and the Japanese Honda-sponsored vehicle. The "Spirit of Biel-Bienne II", designed and engineered by Rene Jeanneret, carried Swatch racing colors to the finish line General Motors first crossed in 1987.

Low Drag Coefficient

The "Spirit's" extremely low drag coefficient, perfected at the Swiss Air Force facility, and advanced solar technology contributed to this impressive win. The technical systems of the "Spirit of Biel-Bienne II" proved so reliable the team experienced no major setbacks. In fact, 'punctures' or flat tires, caused by using maximum tire pressure to reduce friction, gave the Swatch/Biel team the only regular trouble. However, the efficient crew was able to charge both front tires and get back on the road again in the space of four minutes.

Weather

The "Spirit of Biel-Bienne II's" time was just two hours over the time set by the General Motors "Sunraycer" under ideal conditions in 1987. The "Spirit" met with inclement weather including strong headwinds and rain which slowed the Swatch/Biel team's time on Day Four when the "Spirit" averaged only 31 mph and a distance of only 281 miles. The first day of the race also was affected when poor weather reduced driving time from nine hours to eight.

The Goal

The goal of the World Solar Challenge is to prove that solar powered vehicles are capable of efficiently travelling long distances. Hans Tholstrup, race organizer, firmly believes solar cars will replace conventional vehicles within 20 years. According to Tholstrup, "In 100 years, people are going to look back on this rally the same way we do the Wright brothers. It's that important." If this prediction is correct, the Swatch/Biel "Spirit of Biel-Bienne II" will go down in the records of solar-car development as the vehicle from Switzerland that took on the automobile giants of the world - and won.

The Cost

The "Spirit", costing 900,000 Swiss francs (approx. US $700,000), has been termed by Rene Jeanneret, head engineer, a "technical marvel" achieving 1.35 horsepower with 94% efficiency. The Swatch/Biel vehicle transmits 86% of the accumulated solar energy to the drive wheel. In other words, the Swatch/Biel vehicle is capable of reaching 43.2 mph using solar energy alone.

Access

Dorf & Stanton, Amy-Beth Chamberlin or Caryl Svendsen, 111 5th Ave, New York NY 10003, 212-420-8100 • 800-223-2121.

Technical Specifications for the Solarmobil Spirit of Beil / Bienne II

Car body:

General properties– monoposte composite body for light weight and low air resistance.
Construction form– fiber reinforced body structure employing strengthening ribs of sandwich construction and an outer hand laminated layer.
Materials– epoxy resin reinforced by carbon and aramid fibers.

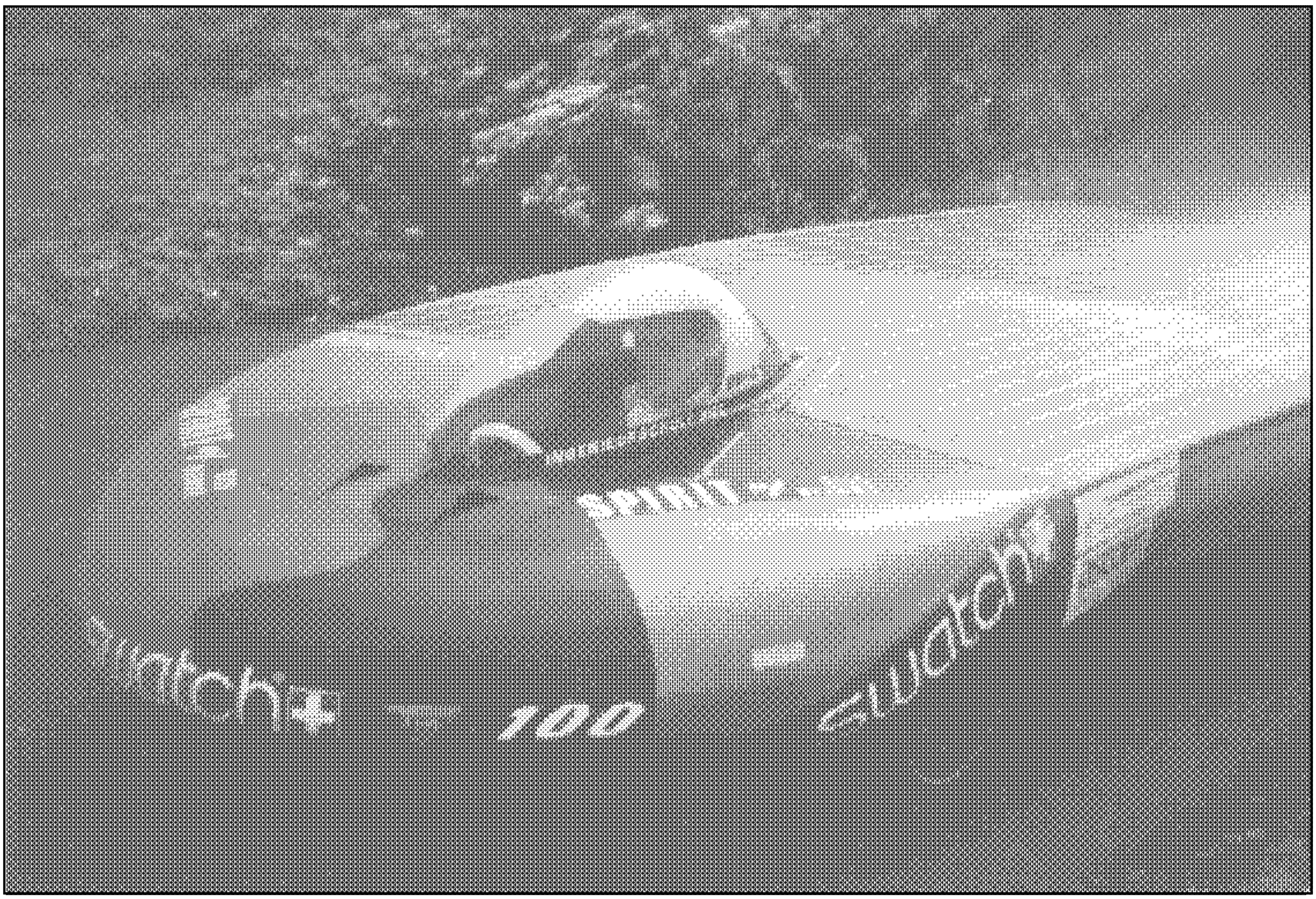
Physical Specs

Weight without electronics and PVs – 66 kg.
Drag coefficient CW – 0.13
Face surface area – 1.1 square meters
Length – 5620 mm
Width – 2000 mm
Height – 1000 mm
Body manufacturer: Bucher Lightweight Constructions, CH-117 Fällanden

Mechanical Elements

Front Suspension – double triangle transverse control linkage with hydropneumatic suspension.
Rear suspension – longitudinal oscillator in the center of the car with incorporated strat up bucking eliminator.
Tires – double racing bike tires 26 inch, 19 mm wide; single tire Bike-Slick 26*1.25"
Front brake – hydraulic disc brake
Rear brake – locking brake
Steering – steel cable steerage
Mode of driving – via chain on the rear wheel

Below: Powered by photovoltaic cells and weighing in at 561 pounds (with driver), the Spirit proves that solar cars work!



Electric Elements

Photovoltaic array

PV output power – 1300 Watts at 25°C.
PV efficiency – 17%
PV surface area – 7.67 square meters
PV cell thickness – 1.3 mm
Weight of PV array – 17 kg.
PV array manufacturer – Telefünken Systemtechnics

Maximum Power Point Tracker

Type – upconverter developed by the School of Engineering
Nominal power – 220 Watts
Efficiency at nominal power – 98.6% at 30°C.
Efficiency at 5% nominal power – 93%
Weight – 0.4 kg.

Battery

Electrochemical type – silver–zinc cells. The battery is composed of 86 series wired cells, each 1.5 VDC
Battery voltage – 129 VDC
Battery electrical capacity – 25 Ampere-hours at C/5 rate
Battery weight – 38 kg.
Battery manufacturer – Eagle-Picher USA

Motor

Type – synchronous employing permanent magnets
Nominal power – 1100 Watts
Peak power – 5000 Watts
Efficiency – 94.5%
Weight – 4.2 kg.

Electronic Drive Units

Type - inverter employing MOSFETs for high efficiency and system control.
Nominal power – 1100 Watts
Peak power – 7000 Watts
Efficiency – 97%
Weight – 5.1 kg.

Instrumentation

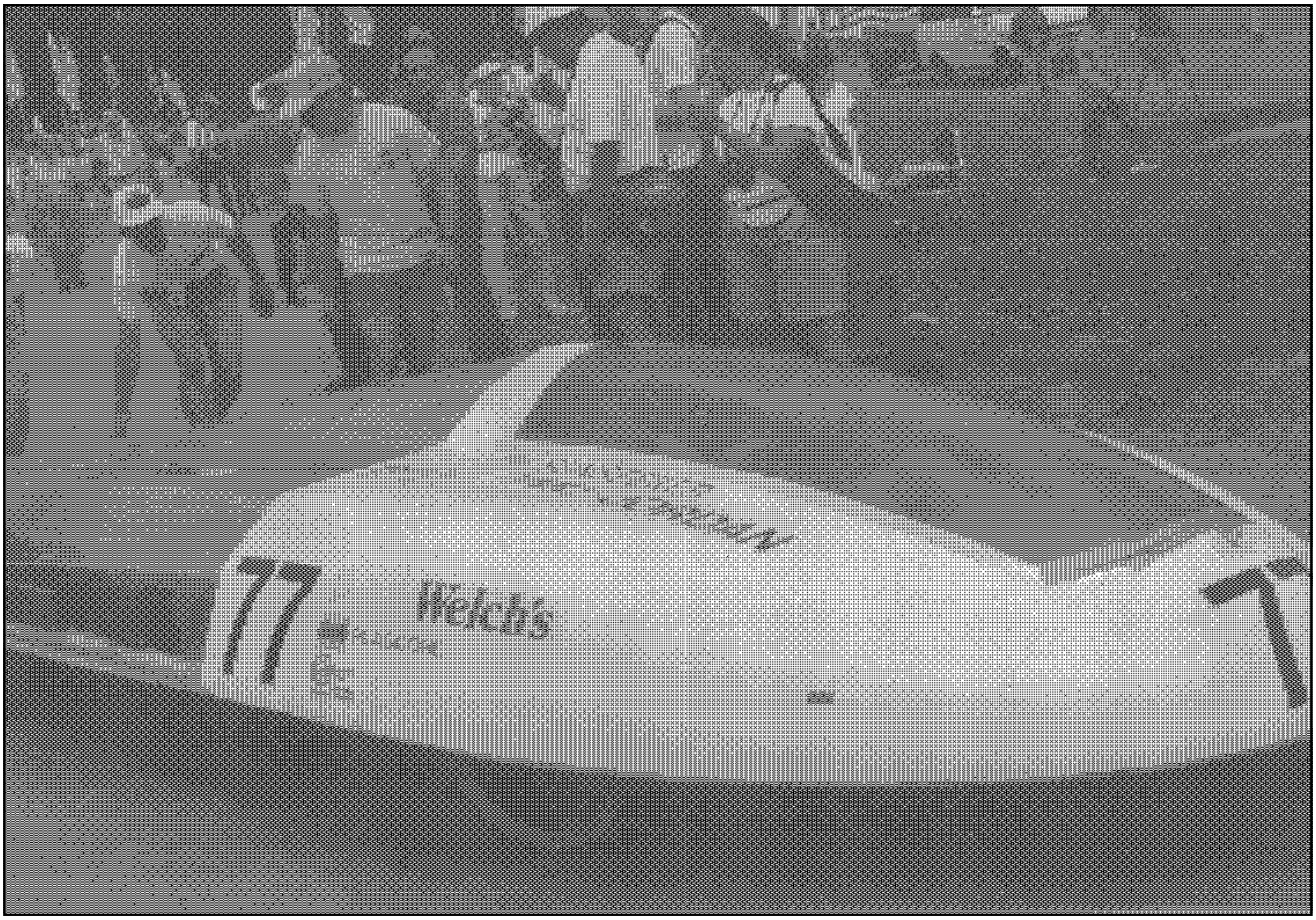
The following functions are instrumented: battery voltage, ampere-hour metering on battery's capacity, current from each of the seven power point trackers, tachometer, PV array output power, and power consumption of the electronics.

Lighting

Stop lights, direction indicators, hazard warning flashers supplied by a separate battery.

Vehicle Weight

Empty – 175 kg.
Total weight including driver – 255 kg.



Above: The WMU/Jordan Sunseeker during the 1990 GM Sunrayce.

The Electric-Vehicle Maintenance Program At Jordan College Energy Institute

Paul E. Zellar

In 1989 Jordan College Energy Institute (JEI) formed a partnership with Western Michigan University (WMU) to build and race a solar powered car, the Sunseeker, in the 1990 General Motors Sunrayce from Florida to Michigan. JEI had expertise in building light-weight racing vehicles. Despite an acute lack of funds, our entry, the Sunseeker, came in eighth in a field of thirty-two.

The cars designed for this race are, of course, not suitable for everyday driving, but they do have some lasting benefits for the industry and for JEI. A race has long been used to hasten development of a transportation device. The Indianapolis 500 has had significant impact on the automotive industry; the Cleveland Air Races have helped aviation to build safer, more efficient aircraft.

Those of us at JEI who worked on the Sunseeker project were struck by how very little attention is paid by academic institutions to education in the area of maintenance of electric vehicles. The comment heard most often from potential employers is that they have to train people with no previous experience for the work. Even graduates of electrical and electronics programs in which the emphasis is on AC and low-current DC power know very little about the operation and repair of electric vehicles. We at JEI decided to meet this need by creating a college program in electric vehicle maintenance. JEI has consistently taught other ways of doing things than the standard one of bigger is better, and it is the only college in Michigan to have continuously offered programs in alternative energy since the seventies. Founded in 1967, JEI now offers, in addition to certificates, the Associate of Applied Science and the Bachelor of Science degrees.

THE JEI ELECTRIC VEHICLE PROGRAM

The First Year

To supply the demand for education in the maintenance of electric vehicles, we first contacted electric vehicle repair facilities to

determine the skills needed by their technicians. Employers consistently demand more than technical skills from their employees. Communications, math, and social abilities were also needed. We therefore considered the additional subjects required for an associate degree program. That led us, while designing the new program, to concentrate as many as possible of the program prerequisites in the first year, thus allowing transfer students who had these common classes to begin studies for their major immediately upon entering JEI. The only technical requirement we specified for the first year was a course in basic electricity. It seemed to us imperative that a person entering the program in the second year must have an understanding of Ohm's and Kirchoff's Laws, of AC and DC theory, and of common electrical devices and their connections. In addition to this basic technical preparation, the new first-year program prerequisites included two semesters of English and one semester each of microcomputer applications, humanities, social studies, business, algebra, and accounting.

The Second Year

In the electric-vehicle-maintenance curriculum itself, we kept an existing course, Control Systems, and added other courses demanded for a complete preparation in the field. These are Motors and Generators, Digital Logic, Inverters and Battery Chargers, and Energy Storage. This series has the advantage that it complements our solar and wind studies. The program also has vehicle mechanics and a practicum. An internship may be substituted for the practicum, which is a period of actual repair of electric vehicles, either at JEI or elsewhere, under the supervision of an expert with proven credentials.

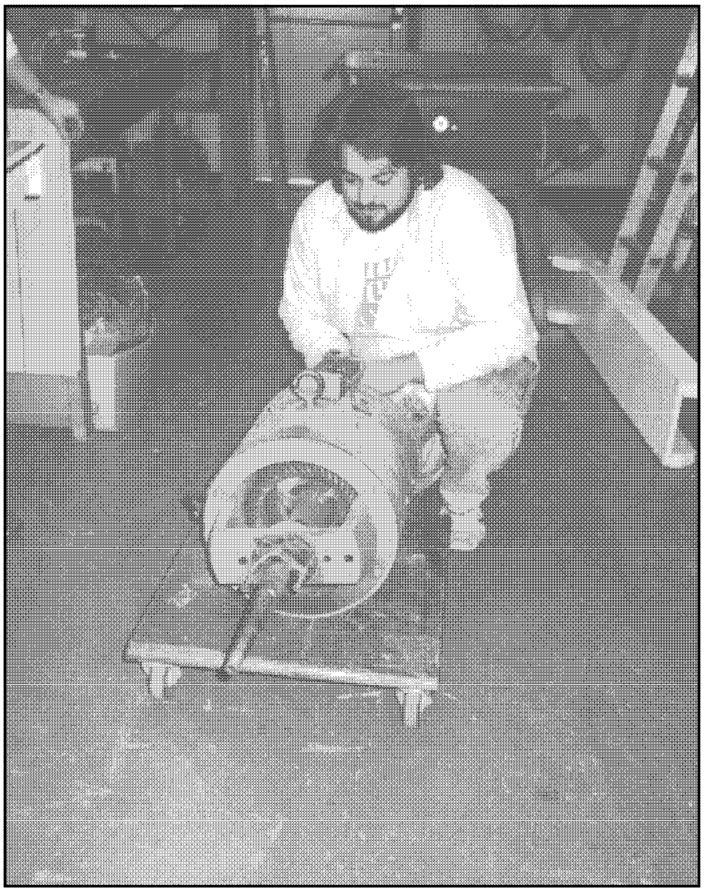
Control Systems covers basic electrical control devices and methods, Ladder diagrams, and both relay and solid-state switching operation. It gives the foundation for the course in Inverters and Battery Chargers.

Inverters and Battery Chargers covers the theory and operation of typical solid-state inverters and battery chargers, including transistorized motor-speed controls. The solid-state speed controller is a huge step forward in making acceleration smoother and in increasing reliability. Older control devices used an accelerator pedal to switch in resistor combinations to control motor current in steps. This was a jerky and wasteful system, because precious energy from the battery was converted to heat in the resistor. The solid-state, or pulse-width-modulated controller (PWM), applies the full battery voltage to the motor, but only for a brief instant, or pulse. The duration, or width, of the pulse is varied by the position of the accelerator pedal. Pulse width can also be controlled automatically by such things as vehicle speed, motor speed, and maximum settings for electrical current. Not only is the adjustment smoother, but the controller is far less subject to burnout than are hot resistors, and, in stop-and-go driving, the range of the vehicle can be extended. Regenerative braking, in which the motor is used as a generator during periods of deceleration or downhill runs, is much easier to employ with a solid-state controller than without it. Many modern controllers also have a built-in converter that supplies 12-volt power from the vehicle's higher-voltage battery. Older techniques of tapping a battery at 12 volts to run lights, radio, fans and other appliances result in unequal charges on the cells of the battery and shorten its life. Carrying an extra 12-volt battery for these accessories also works, but then there is a weight penalty and greater complexity in charging. Developments in this area will be added as they occur.

Motors and Generators is a study of those devices in all their variety, with an emphasis on DC equipment. The laboratory includes teardown, examination, repair and reassembly of motors and generators. Improvements in motor technology offer great promise in the area of development of higher efficiency. Motors are now on the market that offer weight and reliability advantages over the old standby series-wound units still found in the bulk of electric vehicles. The series-wound motor has the advantage that the strength of its field varies directly with the power needed by the motor, but gains that advantage at the cost of field coils that are large and heavy, that consume electrical energy, and that add heat to the motor. New rare-earth permanent-magnet motors give us a strong magnetic field without these drawbacks. Other advances have been made by eliminating the brushes and commutators of DC motors, which contributes to prolonging their life and increasing their efficiency. As the innovations develop, they will be added to the content of the course.

Energy Storage teaches safe and approved methods of testing, maintaining and replacing energy-storage devices. While this covers fuel cells and fly wheels, Hydraulic pressure and other storage mediums, the main emphasis of the course is on chemical storage cells. Battery technology is one area where developments are really happening fast. For instance, lead/acid batteries are much more reliable than their ancient counterparts. Announcements of new miracle batteries abound, but lead/acid remains the most economical battery for mass production. This is being challenged by the new sodium/sulphur batteries currently

Above: JEI students Terry Parker and Rosemary Norman remove the motor from a Citi-Car for cleaning and testing.



Above: Terry Parker, a JEI EV student examines a Jacobs wind generator in JEI's Motors and Generators Lab.

entering the marketplace, which can store more energy in a given weight or volume. This energy density is the type of improvement needed, if it can be achieved at a reasonable cost. The nickel/cadmium battery has many good characteristics but it is heavy, expensive and made of toxic material. Nickel/hydride batteries have been developed that should give equal performance with a quarter of the weight, smaller bulk and hopefully, lower cost.

Another exciting development in the energy storage for electric vehicles, which our course at JEI will follow with interest, is the area of fuel cells. A fuel cell is capable of converting hydrogen and oxygen into electricity with high efficiency. New materials and techniques are reducing the size, weight and cost of these devices. The fuel cell could be used in a hybrid vehicle, an electric car with a charging device built in. This device is usually a gasoline engine or solar array, but the fuel cell would substitute admirably. It can either provide an alternative to battery power while driving, or supplement the battery to extend the range of the car. Hydrogen storage is difficult at present because of current technology. To carry a sufficient quantity of gas, one needs large containers or high pressures. This problem is being worked on in various ways, and a feasible system may soon be ready for production. Should it prove attractive, the problem will then become one of finding the necessary hydrogen. How do we set up "hydrogen filling stations" before the demand for them exists? One answer may lie in the fact that methanol is an alternate fuel for fuel cells, and methanol can be dispensed from existing gas stations. This may provide a refueling method with our present system until the demand for hydrogen is met by constructing the needed facilities.

Vehicle Mechanics teaches established methods of construction and maintenance of the suspension, steering, braking, and transmission systems used in electric vehicles, stressing the proper use of hand tools. Automobiles are currently undergoing drastic weight-reducing measures. These changes will also be closely followed by everyone with an interest in electric-vehicles, since the weight affects all the mechanical portions of the car.

The Practicum gives students an opportunity to put into actual practice all the skills required to maintain electric vehicles. Sadly, the vehicles available to us now are limited in number and variety. We have two electric cars that have come to us through donations, and an instructor lends us his vehicle as needed. All of these are Vanguard Citi-Cars, and one has been stripped to the chassis for students' use. This is a drivable vehicle with an easy access to its parts for routine maintanence as well as experimentation. We also use the Sunseeker race car in this way, and will use it as the foundation for new cars that we will enter in future competitions.

Can You Help?

Generous donors have given us a restorable golf cart and an electric tractor, both very useful to the program. But we need many other representative electric vehicles, most notably a car with a solid state speed controller, an electric forklift, a new golf cart and a and a wheel chair. We also need examples of the various types of batteries and their chargers, as complete a collection as possible of such parts for study as motors and controllers, and repair manuals for all types of electric vehicular equipment. Our funds are severely restricted, and we encourage donations in all areas of need. Since JEI is a nonprofit organization, all contributions are tax deductible. We welcome your inquiries.

In Conclusion

Continuing developments in this country and abroad point up the timeliness of JEI's program in electric-vehicle maintenance. GM's Impact and rumors about the company's secret Project Freedom four-wheel-drive electric vehicle amply demonstrate the interest in Detroit. California's recent regulations mandate the sale of electric vehicles in their state by 1998. It is estimated that the number of electric vehicles that must be built to meet this demand will total half a million units by the year 2003. Will New York follow suit? If so, the demand for electric vehicles will be vastly greater, and the need for mechanics qualified to service this great surge is obvious.

Conversations with those in the industry persuade us that our graduates will be well received in the job market. The number of electric vehicles is already increasing rapidly. The program we have developed will undoubtedly change as we all learn more, but the emphasis will stay on teaching students the basic principles, the proper use of repair manuals, and the value of personal initiative. This is a new program. The students who have passed through it are still few, but they are enthusiastic and well prepared to enter a growing field. If your interests are in the challenge of developing and maintaining electric vehicles, come and look us over.

Access

Jordan College Energy Instiue is located at 155 Seven Mile Rd, Comstock Park, MI 49321, or telephone 616-784-7595.

Preliminary Notes From the EDTA Trenches

by Stan Krute

I was quite excited by the articles in HP #20 on using EDTA to rejuvenate lead-acid batteries. I've done some experimenting of my own the past few weeks, and want to share the early results.

About My Battery Pack

I have eight Trojan L-16 batteries in my pack. Each battery consists of three cells. Each cell has a voltage a bit over 2 volts. The cells are connected in series, so each battery has a voltage a bit over 6 volts. A pair of batteries is then connected in series, to produce a voltage a bit over 12 volts. The four battery pairs are then connected in parallel, which keeps the voltage at 12 volts while upping the amperage.

My battery pack has been in use for 6.5 years. Much of that time has been rough. During the first 5 years, I was working away from home for extended periods. I didn't have solar panels. I didn't have Hydro-Caps. Though I'd leave the batteries well-charged, they'd slowly discharge and get low on electrolyte while I was gone.

For the past 1.5 years, things have been better. I've been home, have a roof full of solar panels, and have Hydro-Caps installed. I'm able to make sure the voltage and electrolyte levels stay healthy.

Lead-acid batteries are unforgiving, however. Those first 5 years did some damage. Though I don't have fancy instrumentation, I could tell that the pack had lost its snap. It discharged too quickly, and woke up too slowly in the morning as the sun and panels started pouring energy in. The voltage variance between cells was growing.

A Modified Plan of Action

Then came the EDTA article. I was excited. I decided to act.

Richard Perez mentioned that the technique he and George Patterson used was not only radical, but difficult. They had flushed and drained their experimental batteries several times. These L-16s are big, heavy batteries. So he suggested a treatment modification: just add the EDTA to the batteries. No repeated flush and drain. I asked what would happen to the crap the EDTA would form when it combined with the trouble-making lead sulfate it was removing. Richard said that this chelate should settle to the bottom of the battery cases, and there was plenty of room for it there, since the battery plates only come within an inch or two of the case bottoms.

Rounds One and Two

I purchased 1 kilogram of EDTA, which by the way stands for ethylenediamine-tetraacetic acid. The kind I purchased is a Tetrasodium Salt: Hydrate manufactured by the Sigma Chemical Company of St. Louis, Missouri. Its chemical formula is $C_{10}H_{12}N_2O_8Na_4$. On December 20th I added 24 tablespoons of the chemical to 36 ounces of warm distilled water. I shook it up, then set it next to the wood stove. After 10 minutes the solution was clear and fully dissolved. I added 1.5 ounces of the solution to each of my batteries' cells. Thus, each cell received 1 tablespoon of the chemical in solution.

Two and a half weeks later, on January 7th, I repeated the procedure, adding another 1 tablespoon of the chemical in solution to each cell.

Some Non-Numeric Observations

I'll get to numbers in a moment, but first want to share a few qualitative observations.

First: The battery pack feels perkier. Its voltage rises faster in the mornings. It doesn't go so low at night, as I sit draining it with my big evening load: computer, printer, large computer screen, color television, and fluorescent light (20 amps all told).

Second: the cells in two of my batteries had an especially noticeable reaction when the EDTA solution was added on January 7th. There was immediate bubbling, and within an hour a large amount of white material coated the tops of the plates. It looked like a small snowstorm had occurred in those cells. Two weeks later, the material is still there, although there is less of it. This white material, which I assume is a product of the EDTA reaction, also formed in the other battery cells, but to a much lesser degree. I am keeping a careful eye on these two batteries; so far there is no major voltage degradation.

Third: there are white deposits on the tops of each cell around the HydroCaps. I assume this is also the EDTA chelate. It is greatest on the two cells noted in the previous paragraph.

Why Cell Voltage Data

In a healthy battery pack, the voltages of the individual cells are equal. In a sick pack, the cell voltages vary. Since I currently lack the instrumentation required to take direct battery pack performance data -- the ratio of watts in to watts out -- I rely on cell voltage data as a health indicator.

I've taken cell voltage data on four occasions: just before EDTA treatment 1, just before EDTA treatment 2, two days after EDTA treatment 2, and twelve days after EDTA treatment 2. We've printed the first, second, and fourth data samples.

About the Data

I have eight batteries. Each data sample shows the measured voltage of each of the three cells in each battery.

Beneath each battery's voltage I derive seven statistical measures. These help analyze the raw cell voltage data.

First is the difference between a cell's voltage and the average voltage of all cells in the pack. This is given as a positive number for each cell in the battery. We want this to be as small as possible.

Second is the average of these cell::pack deviations for the three cells in the battery. We add up the three cell deviations and divide by three. We want this to be as small as possible.

Third is the difference between a cell's voltage and the average voltage of all cells in the battery. This is given as a positive number for each cell in the battery. We want this to be as small as possible.

Fourth is the average of these cell::battery deviations for the three cells in the battery. We add up the three cell deviations and divide by three. We want this to be as small as possible.

Fifth is the average voltage of all cells in the battery.

Sixth is the standard deviation of cell voltages. This is figured by applying the standard deviation formula you'll find in any statistics

Data Sample #1

date:	12/20/90
time:	11 am

system voltage:	12.58 volts
system amperage:	9 amps
system temperature:	25° Fahrenheit

notes: Data taken before adding 1 Tablespoon EDTA per cell. Each Tablespoon of EDTA was dissolved in 2 ounces of distilled water.

	battery 1			battery 2			battery 3			battery 4		
back row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.04	2.05	2.04	2.07	2.05	2.07	2.07	2.06	2.07	2.06	2.07	2.07
Absolute Cell Deviation From Pack	0.028	0.018	0.028	0.002	0.018	0.002	0.002	0.007	0.002	0.007	0.002	0.002
Average Absolute Cell Deviation From Pack		0.024			0.008			0.004			0.004	
Absolute Cell Deviation From Battery	0.003	0.007	0.003	0.007	0.013	0.007	0.003	0.007	0.003	0.007	0.003	0.003
Average Absolute Cell Deviation From Battery		0.004			0.009			0.004			0.004	
Battery Average Cell Voltage		2.043			2.063			2.067			2.067	
Battery Cell Voltage Standard Deviation		0.005			0.009			0.005			0.005	
Battery Maximum Cell Voltage Difference		0.010			0.020			0.010			0.010	

	battery 5			battery 6			battery 7			battery 8		
front row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.07	2.08	2.07	2.08	2.06	2.08	2.07	2.09	2.08	2.07	2.08	2.07
Absolute Cell Deviation From Pack	0.002	0.013	0.002	0.013	0.007	0.013	0.002	0.023	0.013	0.002	0.013	0.002
Average Absolute Cell Deviation From Pack		0.006			0.011			0.013			0.006	
Absolute Cell Deviation From Battery	0.003	0.007	0.003	0.007	0.013	0.007	0.010	0.010	0.000	0.003	0.007	0.003
Average Absolute Cell Deviation From Battery		0.004			0.009			0.007			0.004	
Battery Average Cell Voltage		2.073			2.073			2.080			2.073	
Battery Cell Voltage Standard Deviation		0.005			0.009			0.008			0.005	
Battery Maximum Cell Voltage Difference		0.010			0.020			0.020			0.010	

Pack Average Cell Voltage	2.068
Pack Cell Voltage Standard Deviation	0.012
Pack Maximum Cell Voltage Difference	0.050
Maximum Pack Average::Battery Cell Voltage Difference	0.014
Maximum Pack Average::Battery Average Voltage Difference	0.024
Average Battery:Pack Voltage Difference	0.006

Data Sample #2

date:	1/7/91
time:	9:30 am

system voltage:	12.25 volts
system amperage:	0 amps
system temperature:	45° Fahrenheit

notes: Data taken before adding a second 1 Tablespoon of EDTA per cell. When EDTA was added to cells in batteries 6 and 7, immediate bubbling action and precipitation was observed.

	battery 1			battery 2			battery 3			battery 4		
back row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.02	2.02	2.02	2.04	2.01	2.03	2.03	2.03	2.03	2.03	2.03	2.03
Absolute Cell Deviation From Pack	0.010	0.010	0.010	0.010	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average Absolute Cell Deviation From Pack		0.010			0.010			0.000			0.000	
Absolute Cell Deviation From Battery	0.000	0.000	0.000	0.013	0.017	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Average Absolute Cell Deviation From Battery		0.000			0.011			0.000			0.000	
Battery Average Cell Voltage		2.020			2.027			2.030			2.030	
Battery Cell Voltage Standard Deviation		0.000			0.012			0.000			0.000	
Battery Maximum Cell Voltage Difference		0.000			0.030			0.000			0.000	

	battery 5			battery 6			battery 7			battery 8		
front row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.04	2.03	2.05	2.03	2.03	2.03	2.03	2.03	2.04	2.02	2.04	2.03
Absolute Cell Deviation From Pack	0.010	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.010	0.000
Average Absolute Cell Deviation From Pack		0.010			0.000			0.003			0.007	
Absolute Cell Deviation From Battery	0.000	0.010	0.010	0.000	0.000	0.000	0.003	0.003	0.007	0.010	0.010	0.000
Average Absolute Cell Deviation From Battery		0.007			0.000			0.004			0.007	
Battery Average Cell Voltage		2.040			2.030			2.033			2.030	
Battery Cell Voltage Standard Deviation		0.008			0.000			0.005			0.008	
Battery Maximum Cell Voltage Difference		0.020			0.000			0.010			0.020	

		% change from first sample
Pack Average Cell Voltage	2.030	
Pack Cell Voltage Standard Deviation	0.008	-33%
Pack Maximum Cell Voltage Difference	0.040	-20%
Maximum Pack Average::Battery Cell Voltage Difference	0.010	-29%
Maximum Pack Average::Battery Average Voltage Difference	0.010	-59%
Average Battery:Pack Voltage Difference	0.005	-17%

Data Sample #4

date:	1/19/91
time:	2;25 pm

system voltage:	12.89 volts
system amperage:	14 amps
system temperature:	50° Fahrenheit

notes: 12 days after last EDTA treatment. still white precipitate on battery tops & inside cells. especially in cells of batteries 6 and 7. like a light snowfall.

	battery 1			battery 2			battery 3			battery 4		
back row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.13	2.14	2.13	2.14	2.14	2.13	2.13	2.14	2.13	2.13	2.14	2.13
Absolute Cell Deviation From Pack	0.003	0.007	0.003	0.007	0.007	0.003	0.003	0.007	0.003	0.003	0.007	0.003
Average Absolute Cell Deviation From Pack		0.004			0.006			0.004			0.004	
Absolute Cell Deviation From Battery	0.003	0.007	0.003	0.003	0.003	0.007	0.003	0.007	0.003	0.003	0.007	0.003
Average Absolute Cell Deviation From Battery		0.004			0.004			0.004			0.004	
Battery Average Cell Voltage		2.133			2.137			2.133			2.133	
Battery Cell Voltage Standard Deviation		0.005			0.005			0.005			0.005	
Battery Maximum Cell Voltage Difference		0.010			0.010			0.010			0.010	

	battery 5			battery 6			battery 7			battery 8		
front row	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3	cell 1	cell 2	cell 3
of pack	2.13	2.15	2.13	2.12	2.13	2.13	2.13	2.13	2.13	2.13	2.14	2.13
Absolute Cell Deviation From Pack	0.003	0.017	0.003	0.013	0.003	0.003	0.003	0.003	0.003	0.003	0.007	0.003
Average Absolute Cell Deviation From Pack		0.008			0.006			0.003			0.004	
Absolute Cell Deviation From Battery	0.007	0.013	0.007	0.007	0.003	0.003	0.000	0.000	0.000	0.003	0.007	0.003
Average Absolute Cell Deviation From Battery		0.009			0.004			0.000			0.004	
Battery Average Cell Voltage		2.137			2.127			2.130			2.133	
Battery Cell Voltage Standard Deviation		0.009			0.005			0.000			0.005	
Battery Maximum Cell Voltage Difference		0.020			0.010			0.000			0.010	

		% change from first sample
Pack Average Cell Voltage	2.133	
Pack Cell Voltage Standard Deviation	0.006	-50%
Pack Maximum Cell Voltage Difference	0.03	-40%
Maximum Pack Average::Battery Cell Voltage Difference	0.010	-29%
Maximum Pack Average::Battery Average Voltage Difference	0.006	-74%
Average Battery:Pack Voltage Difference	0.002	-67%

text to the battery's cell voltages. We want this to be as small as possible.

Seventh is the maximum voltage difference between any two cells in the battery. We want this to be as small as possible.

After giving the data and these statistics for each cell and battery, I derive six more statistical measures for the pack as a whole.

The first of these is the average voltage of all cells in the pack. I add up all the cell voltages and divide by 24.

Second is the standard deviation of cell voltages. This is figured by applying the standard deviation formula you'll find in any statistics text to the pack's cell voltages. We want this to be as small as possible.

Third is the maximum voltage difference between any two cells in the pack. We want this to be as small as possible.

Fourth is the maximum voltage difference between the average voltage of all cells in the pack and any individual cell. We want this to be as small as possible.

Fifth is the maximum voltage difference between the average voltage of all cells in the pack and the average cell voltage of any battery. We want this to be as small as possible.

Sixth is the average voltage difference between batteries and the entire pack. We want this to be as small as possible.

On the second and fourth samples, I show the percent of change in each of the last five pack statistical measures since the first sample.

Some Interpretation

What we want to see is the cell voltages coming closer together. We want most of the statistical measures to approach zero.

This is what has been happening. By the fourth sample, the data seems significant. The changes in the last five pack statistical measures range from 29 to 74 percent. They are going in the right direction -- down.

I am a very happy puppy so far. I shall give further reports as the experiment continues.

Access

Stan Krute is a pinhead. He may be reached at 18617 Camp Creek Road, Hornbrook, California 96044. • 916-475-3428.

And more EDTA feedback…

Conrad Heins

Your article on using EDTA to cure sulphated batteries was fascinating. We will experiment ourselves on some of the badly sulphated telephone batteries (2 volt, 1200 amp-hour) we have at the school. Speaking as a chemist I would say that EDTA (or its sodium salts) OUGHT to do the job (in fact, why didn't I think of it?) I would guess that it works something like this:

EDTA dissolves the lead (II) sulphate that has undergone sulphation (a crystalline rearrangement that greatly reduces the surface area and hence the reactivity of the lead (II) sulphate that was formed originally).

Because EDTA forms a chelate selectively with the lead (II) ions (as opposed to metallic lead or lead (IV)), it very gently removes the unwanted material without clogging up or otherwise damaging the highly porous structure of the active parts of the electrodes.

I suspect that the Trojan L16s have a large excess of electrode material, so you can remove an entire charge's worth in order to bring them back to life. The process probably reduces the number of deep cycles and maybe some of the amp-hour capacity, but what a trade-off!

Conrad Heins, Comstock Park, MI

And even more EDTA feedback…

Paul Isaak

I was absolutely fascinated by your article "New Life for Sulphated Lead-Acid Cells" in the December 90-January 91 issue of HOME POWER.

One of the reasons for my fascination is that I have used EDTA intravenously for almost 10 years in treating lead poisoning and vascular insufficiency due to plaques in the arteries. The other reason for my fascination is that I have a remote cabin across Cook Inlet at which at which I have to supply my own electrical power. I am currently on my 3rd set of batteries (in about 12 years) charged by a Lister Diesel generator. They are about ready to give up. I just last week culled out 8 out of 16, 6 volt batteries because of dead cells. I have a Best 48 volt inverter with 5000 watt continuous duty rating and a 20,000 watt surge capacity.

Three years ago I discarded 24 - 2+ Volt deep cycle batteries because they would no longer a charge. The batteries I now have were old when I bought them but I got them for 2 bucks apiece and they have served 3 years so I probably got my money's worth. In retrospect, I am wondering if the 24 (telephone standby) batteries were sulphated and consequently not able to hold a charge. I may have discarded them unnecessarily.

As you point out in your article, EDTA is a relatively harmless compound and can be used with relative safety (even intravenously) provided certain precautions are observed. The FDA even condones its use for lead poisoning because it effectively pulls out the stored lead (usually in the bones and teeth) from the body which is present from prolonged exposure to lead. (Radiator repair men are especially at risk and may have various symptoms due to both chronic and acute exposure.) I guess plumbers are now prohibited from using lead solder when doing plumbing in new homes.

Warm Regards, Paul G. Isaak, M.D., Box 219, Soldotna, AK 99669

EDTA ACCESS DATA

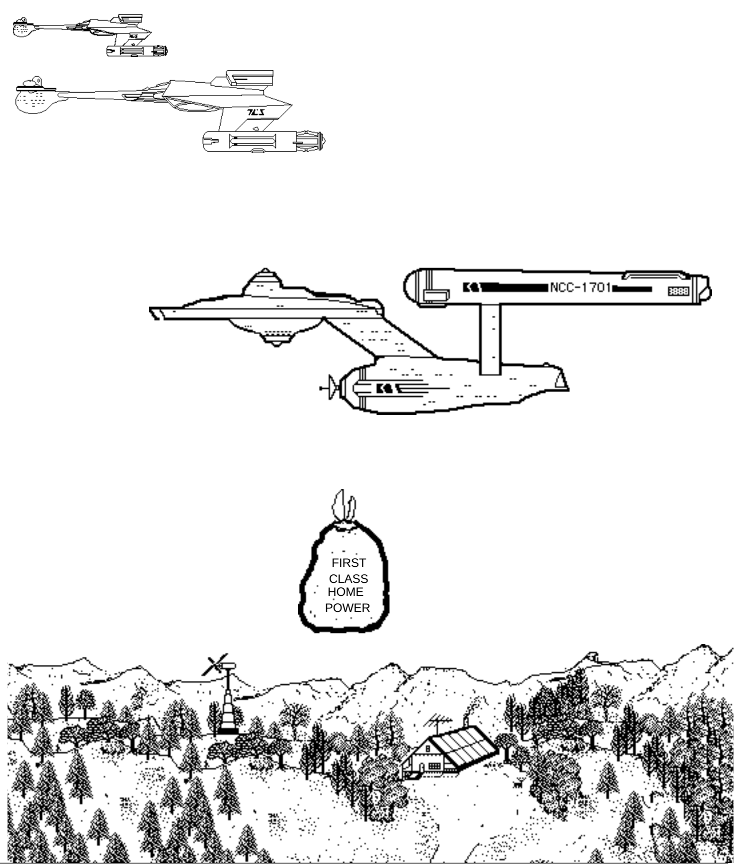
Trailhead Supply
325 East 1165 North, Orem, UT 84057
801-225-3931
Cost: EDTA, $10 per pound ppd.

Bryant Labs
Peter Barnett
1101 5th St., Berkeley, CA 94710
415-526-3141
Cost: $22.50 for 500 grams

High Purity
Peggy
POB 17376, Portland, OR 97217
503-249-2985
Cost: $22.50 for 500 grams

Order the "Tetrasodium salt" version of EDTA.

see page 95



Above: Laura and Saylor Flett in the sun-filled living room of their solar powered home.

Lifestyle Freedom Through Renewable Energy

Kathleen Jarschke-Schultze

From a woman's point of view I have found that a lot of people (mostly women) are surprised that an elegant home may be maintained on renewable energy. Somehow the idea that renewables mean primitive or spartan living has been accepted, mainly by grid users. Comfort, style, & function are all possible. Home power systems are available for every style of living, from small to full-sized family uses.

Location

This home is located 2.4 miles from the closest grid power. To bring power in would cost $60,000.00. Then there would be the monthly bill to contend with, blackouts (especially when it is the coldest and the hottest weather), and power lines spoiling your view. This wooden house sits in a small valley, in the Northern California hills, with a creek running close by. The setting is pastoral. By purchasing the land without any buildings the owners were able to choose their lifestyle right from the beginning.

Function And Style

The kitchen is a rectangle, opening at one end to the dining area, which in turn opens to the living area. The owners have all the conveniences they want. A microwave, a heavy duty mixer, Cuisinart all add to ease the work in food preparation. The hand tiled counters and double sided glass doored cabinets make this a kitchen that is pleasant to spend time in. The polished wooden

floor (refinished gym flooring) spreads into the dining and living areas.

Distinctive Elegance

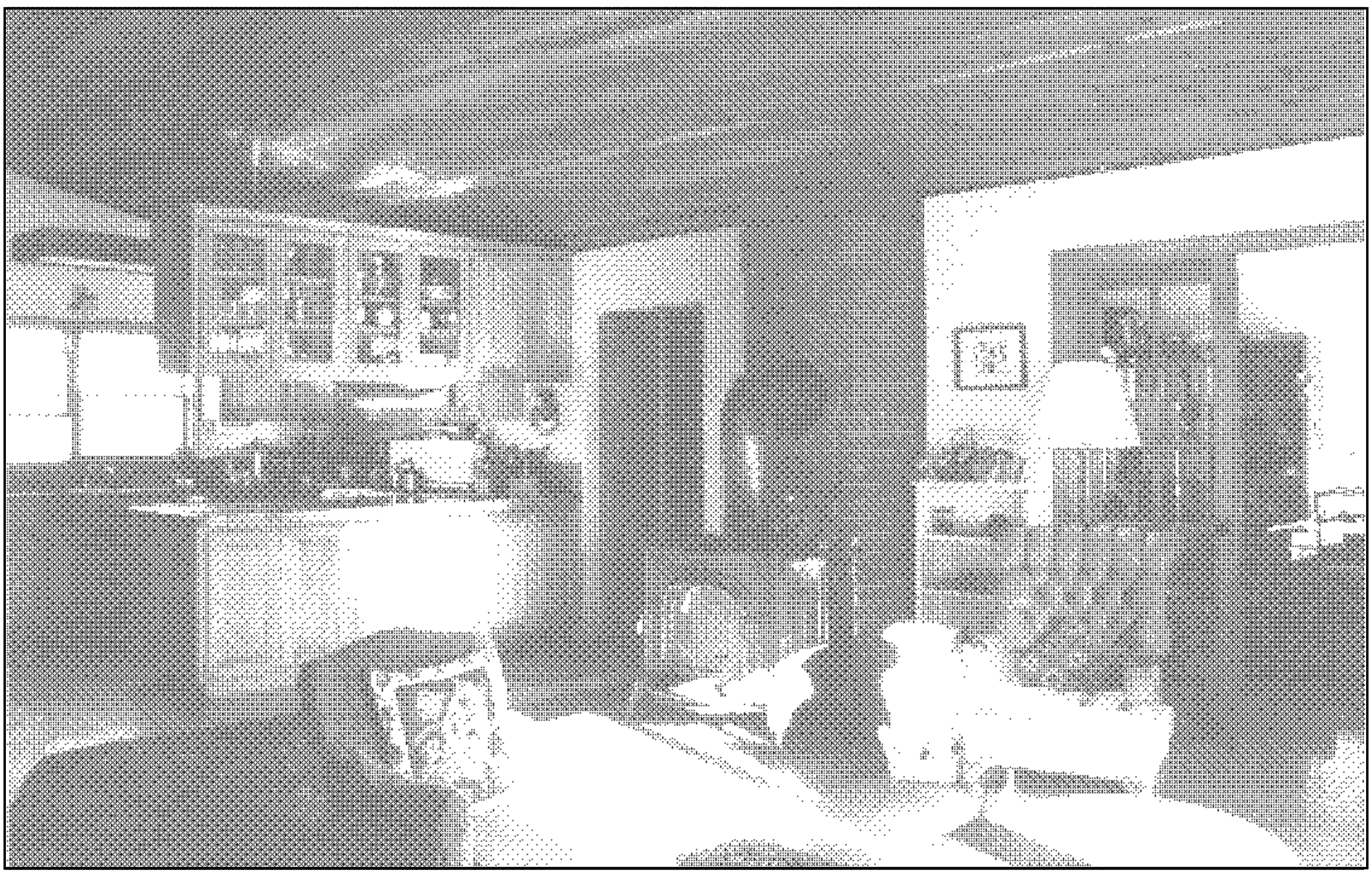
This home boasts a veritable plethora of fine antiques. The dining room table is an old wooden ship's wheel, the living room gleams with the soft tones of polished wood. The style is eclectic as are the owners. The feel is that of a gracious country home. Complete with a TV, stereo system, fish tank, and various lights, some in antique lamps, visitors often don't realize the power is supplied by the eight PVs on the roof. In the library, a computer resides on on old wooden desk, amid tall bookshelves holding a collection of volumes, both attractive and useful. A stained glass window running the length of the room, depicting ducks taking wing from a marsh, tops one bookcase and allows light to pass into the hallway beyond. Double mullioned french doors open back into the living area.

Practicality And Comfort

There is a back porch which opens onto a mudroom, with a bench where you can take off your shoes and muddy boots. Anyone who lives in the country knows how priceless this is. Beyond the kitchen, down the hall way is my favorite, the laundry room. A washer and a dryer reside here along with many cupboards and linen closets. Just beyond that is the main bathroom, complete with a tub and shower. The master bedroom also has a bathroom

Above: This country kitchen contains all the electric conveniences and they are powered by sunshine.

Below: A view from Jim & Laura's living room into the kitchen. In the right edge of the photo is the entrance to the library / computer room. The lighting in this home is mostly fluorescent. Heat is supplied during the winter by the wood stove.



that sports a shower. Give up comfort to live on renewable energy? Not in the least!

To build the home of your dreams, whatever that may be, is not limited by using renewable energy, but greatly expanded. These types of power systems can be added to piece by piece. Just like a collection of fine antiques. You need not do without any conveniences you desire. You only need to define your desires. Your lifestyle is your choice. Spartan or luxurious, you can help save the environment by using renewables in your home. Don't draw away from the unknown. Learn about what choices you have and make them sensibly.

Tech Stuff

If you (or your husband) are interested in the technical information on this particular system please refer to HP#13, starting on Page 7. This will probably answer any questions the power master in your household has. You will see that it is possible, and at this point in world history, preferred. You may also view other pictures of this warm and beautiful home in the same article.

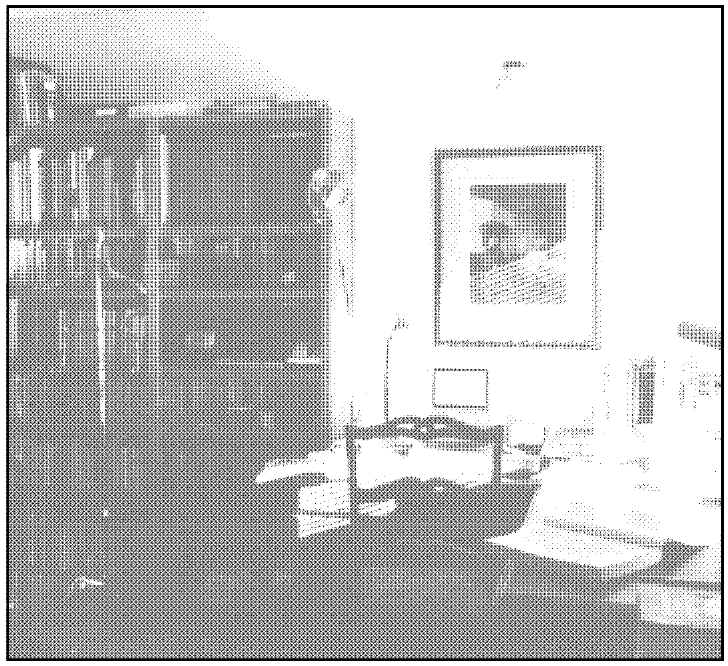
Finite And Infinite

The choice, the dream, the style is yours to contemplate and command. You have an infinite choice of lifestyles before you. Most take very hard work to attain. The world has a finite amount of fossil fuels to power the future. Become part of the Green Dream and help make the earth a better place for future generations while enjoying your time here.

Access

Author: Kathleen Jarschke-Schultze, 19101 Camp Creek Road, Hornbrook, Ca 96044 • 916-485-3401.

Renewable Energy System Designed and Installed by: Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3401.



Above: Jim and Laura's library / computer room. Both Jim and Laura are self-employed and use the two computers (a Mac and an IBM) for their livelihood. All the computer gear is powered by PV produced electricity that is stored in batteries and converted by an inverter.

Crickets In The Country

Wm. J. Schenker, M.D.

K.I.S.S. Keep It Simple, Stupid. I have only one design principle (apart that it should work) whenever I engineer anything: it should be simple. Thus I was deeply smitten by the concept of the Copper Cricket Solar Water Heater when it was first described in these pages (HP #8). It was the design I was waiting for to substitute the sun for our water tank's electric heater. No pumps, no electricity, no wires, no relays, no solenoids, NO MOVING PARTS -- and it would pump from the roof 30 feet above my tank in the basement with no freezeup in our below zero winter weather.

It works

The design is truly elegant, based on the geyser principle that perks your coffee in the percolator every morning. It provides water as hot as 140 degrees on some July and August days in eastern Washington. The rest of the hot summer days gives us around 120° water, and spring and fall provides 90° to 100° water. All of these numbers are for the peak time which is 10 to 3 in the summer and 12 to 2 in the spring and fall.

Some caveats

Sage Advance will sell you a kit with an instruction manual, on a do-it-yourself basis. Don't even consider it unless you're 1) very mechanically inclined, and 2) are a professional heating and air-conditioning installer. Suspecting a tricky installation, and having budgeted for the work, I persuaded the Sales VP, Tom Scott, and Dale Northcutt, Chief Techie, to take time out from a hectic schedule and come up here to do the job.

Hard water - hard times

As it turned out there were some minor surprises, and one major shock: my existing hot water tank was, unbeknownst to me, in its death throes. Usually it's a straightforward procedure to simply remove the lower electric heating element in a two-element tank and replace it with the "cricket" plumbing connection. When Tom and Dale attempted it, they found the hole almost completely plugged up with a calcified iron deposit and the electric element almost completely dissolved. All this comes from living in a hard water area (How does FIFTY - 50 - points of hardness grab you?) I thought I had it licked with a commercial water softener, but apparently there's still a residual problem, especially where water changes temperature suddenly (like around an electric heating element).

Why do I keep thinking of plugged arteries and cholesterol?

So while they worked on the roof installation, I quickly gophered a replacement tank in nearby Yakima. As they were installing the new tank and the cricket gear attached, Tom warned me about the hardness problem: "Make sure you flush this section, that gets the big temperature change, REGULARLY, like every few months -- otherwise it'll plug up and you're in trouble." This would apply in spades in connection with the wood stove water heat exchanger I was planning to build and run in series with the cricket for winter service.

Even experts can make mistakes

The rest of the installation went pretty smoothly, just like you'd expect from two pros. (Only later, when I had to recharge the system myself, did I appreciate their skills.) Nevertheless, even they slipped up. One of the flush valves was put in backwards -- so the part of the loop needing flushing every few months couldn't be flushed. I didn't find this out till the next summer -- because I got sloppy and let the time slip by. (Read below for the details.)

Flexibility is a sign of maturity -- except in copper tubing

The other aspect of the installation which troubled me was not any mistake on their part: they installed the heat exchanger pad to the water tank with flex copper tubing, the standard procedure. DO NOT SPECIFY THE STANDARD PROCEDURE FOR HOOKING UP HOT WATER HEATERS -- DO NOT USE COPPER FLEX TUBING. Reason: unless you live in a part of the country where you can guarantee no earthquake hazard, you're asking for instant geyser games; flex tubing, with water inside it under 30-50 lbs pressure, ruptures when moved as little as 1/2".

I successfully performed this unintentional experiment about 4 years ago on a Sunday morning 15 minutes before leaving for church. The tank was in the way of a door to a storeroom I had just built, and I only needed to rock the tank 1/2" to clear the door ---- ppfffftttttt!!!! Inside of 5 seconds I was being sprayed by scalding water and in two minutes water was puddling in the basement. Miraculously, I got a plumber on Sunday morning and he arrived an hour later for the fix. "Oh yes" he said, "flex pipe will always do that if you move it. As a matter of fact it'll eventually do it even if it isn't moved -- it'll just break down someday." "Oh? How long do you think I can count on the flex tube lasting, typically?" "Maybe 5 years, maybe 10." "Izzat right? You have any SOLID pipe with you in the back of the truck you can replace that flex stuff with, RIGHT NOW?" "Yup."

Remembrances of things past: July 9-10, 1990

That was the week we had temperatures up around 110-112. It was also the week we were to be gone on our 2-day vacation. The cricket manual says if you're gone 3 days or more in the summer make sure to cover the roof collector with a tarp -- to prevent the system from blowing its head of steam, since nobody'll be drawing off shower or dishwasher water. We were safe, with one day to spare -- no need to climb the roof to tarp the cricket in the heat.

Sometime after returning, maybe a week, it seemed we weren't getting that superhot water we were used to. A couple weeks later I climbed the roof and saw the hole where the pressure/heat fuse had blown and realized we had lost the charge. Talked to Sage Advance a few times; we were both convinced it had blown because I hadn't flushed out the heat exchange loop the way I should have.

The Plumber cometh, again

Got the plumber back and together we got the flush valve unscrewed, reconnected in proper orientation, and then rejoined with the various copper fittings and tubes. I now felt confident that with a re-charge of the system up on the roof I'd be back in business making hot water from the sun.

Becoming a Copper Cricket Serviceman

I bought a recharging kit, with vacuum pump, spare cans of methanol, spare fuse plugs, and assorted plumbing hardware. Up on the hot roof. Got it all taken apart, and put together and re-charged (after finding out you must have a "basin wrench" to disassemble and reassemble a couple of parts -- a very handy tool by the way and less than $10 at your local plumbers' supply). ..... No cricket chirping.

Talked to Eldon Haines, in the office. Fine person. Very knowledgeable. Very patient with dumb customers. He pointed out that early production had exchanger pad tubing that had downward-sloping connections instead of upward-sloping, thus preventing proper thermosiphon action. Checked the pipes on my unit. Sure enough the angles were pointing downward instead of upward, assuring there would be a poor flow of hot water and setting me up for a big blowout the next time we ran into a heat wave.

Bend the pipes upward and I should be in business. I did. No chirping.

Confessions of a troubleshooter

Back up on the roof. When confronted with a stubborn technical problem I always assume the proper mental stance. 1st phase: "Why doesn't this stupid thing want to work! The NERVE of it not working for me!" 2nd phase: "God, do I really deserve all this frustration? Other guys never have these problems -- why do You always give them to ME?" 3rd phase: "Maybe I should start checking. Could be a correctable mistake made by somebody (The somebody could even be ME.)" At this point, never before, I usually solve the problem.

Nature abhors a vacuum

I couldn't seem to build a vacuum in the cricket head. It needs about 25 inches of Mercury when cold. Finally, I put my head down by the needle valve (the same kind you use in your car tire) and listened. No hiss. Then, remembering back to the '30s, when people used to fix their own tires, I put a bubble of spit on the valve -- and watched it suck right in. Diagnosis: a leaky valve.

Then I remembered having blown out a valve during the charge phase because I misread the instructions in the manual. Dale sent me a replacement, but it seemed like the old valve was working fine now, so why bother. Except it went subtly bad later. With that out of the way I recharged the cricket. ... No chirping.

Fortunately at that point the actuator used to pull the vacuum fell apart in my hands. Only then did I realize that an even bigger leak was coming from the defective actuator. Eldon sent me a replacement. Re-pulled the vacuum. CRICKET IS CHIRPING BEAUTIFULLY!

Post-mortem

Did me not flushing out the heat exchanger loop cause it to plug up and thereby blow the system? Probably not. When I finally got to flush it out, I got quite a bit of gunk out, but there was essentially a free flow of water there. My opinion is the wrong-angled pipes in early production units was the culprit.

Wrapup

Would I buy the Cricket again? You bet. We had a more conventional type when we lived in California. I've seen a few other kinds of designs. Read about a lot more. The Cricket beats them all. Also Sage Advance are good people: skilled, honest, and supportive. (For example, Tom Scott gave me wonderful design details to build a woodstove water heater and tie it into the cricket, which I did. Works great.) Also they've successfully got the bugs out of the system. Their installation, operation, and maintenance manuals are getting better too.

Finally, I'd rather sweat and strain during installation of a system -- than have to baby sit it during its entire lifetime, with never-ending maintenance routines and frequent maintenance surprises.

Access

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Manufacturer: Sage Advance Corp., 1001 Bertelsen, Suite A, Eugene, OR 97402. 503-485-1947.

AC Computing on a Budget

John C. Osborne

The vast majority of computers were designed for 120 volt ac power. They were not designed for power efficiency. You may still be on the grid and wish to conserve. You may be making your own power and have to conserve. In either case, you can have a fast, capable computer system that consumes about ten times less than a typical system. This makes an AC powered computer available at an attractive purchase price.

Beat The Averages

You can't have everything. But if you are informed and logical, you can do dramatically better. On average, computer owners pay as much for the electricity to run their computers as they do the computers themselves. A $2,000 system may have a $2,000 lifetime electric bill, and that's for grid produced power. Alternative energy costs substantially more. Using clever, aggressive and refined technology, you can do 10 times better.

Scope

This discussion is limited to IBM compatible systems. Standard subsystems built by hundreds of manufacturers allow you to mix and match for the specific trade offs you seek.

The Ease Of Ac Systems

AC powered computers are easy to buy or build. Thousands of choices are available and no modifications are needed. You need an inverter to use DC power, but they are cheap, rugged and versatile. Computers, printers and monitors all need multiple internal voltages at various currents. An inverter lets you completely disregard these details.

The Costs Of Ac Systems

OK, so AC systems look easy. When cost is considered, there is good news and bad news. Initial purchase price is good. Resale value is good. Lifetime cost is bad due to normally high power consumption. This "bad news" is reversible by carefully choosing components.

If you are grid connected...

Many of you are on the grid but dissatisfied with it. Some complain of several momentary power outages per day. This is so hostile to computers that some form of uninterruptible power supply is needed. These can be purchased at most computer supply stores and mail order catalogs. They consist of an inverter, a 12 volt battery, a charger and monitoring/control circuitry. The battery is good for up to a half hour of running time during a power failure. A 600 watt UPS costs about $800. If you can lower the computer's power use, you can spend less on a UPS.

Some of you complain of electric rates of 20 cents/Kilowatt-hour. Reducing your power consumption is certainly in your best financial interests. Some want to conserve energy on behalf of the environment.

If you are off the grid...

You need an inverter. But it is practical to get by with very small units. These are often 90% efficient when run at half of their continuous rating. A reasonably fast and capable ac computer and monitor needs only 35 watts. An ac printer needs only 18 watts printing, 9 when idle and none when turned off. This makes life easier.

Don't Be A Slave To Fashion

The computer industry uses fashion to convince you to buy the latest, fastest, etc. Put logic back into the picture by making the intended applications define the choices. If everything you put on paper is black and white, you don't need a color monitor. If you print thousands of mailing labels, only the speed of the printer makes any real difference. If your documents are small or can be segmented, floppy disks may be adequate. Bigger used to mean more impressive, but an emerging trend is to reclaim desktop real estate with compact systems. This is a trend we can exploit.

But wait, you are not home free yet. Perhaps a different program would speed your work by being more suitable to the task. If you spend less time struggling with your computer, you use less power. Your power consumption is the wattage times the time. Just when you thought it was simple. Consider carefully.

Monitor

The current trend in computer displays is color, multi-sync, VGA, 14 inch screen size and needs 80 watts. But a black and white, Hercules, 9 inch monitor needs under 15 watts. Black and white displays are clear because they don't have convergence problems or dots like color units. Hercules compatibility means a resolution of 720 pixels by 348 pixels which approaches VGA resolution. A 9 inch screen means you sit a little closer. If you must have color, a 10 inch, 1024 pixel by 786 pixel resolution multi-sync unit recently came on the market. Older display standards implemented with the latest technology is the way to win here. For existing systems, a 9 or 10 inch replacement monitor may be the best bargain for reducing power. If cost is no object, LCDs are best. The wattage of the monitor is important because it is always on.

Printer

Lasers are the rage, but their power consumption is 500 watts. Not only is this too high, but lasers are often damaged by the square wave output of inverters. Older printers are also bad choices. Microprocessor control has lowered printer power requirements. Better choices are ink jets and small, slow 9-pin printers. Several models are available for under 20 watts. The ink jets offer output equal to lasers. 9-pins are a must if you need multi-part forms. Power use is not quite the issue it is with monitors because printers often spend more time off than on.

Inside the box

Changing out the monitor and printer is easy, but there are possibilities inside the computer box too. First, don't get a 5 1/4 inch floppy drive. If you have one, replace it with a 3 1/2 inch drive. Those 5 1/4 inch drives use up to 15 watts. The smaller ones use 1.7 watts while running and only 0.03 watts when idle. They hold more data and are faster as well. The only thing the older drives have going for them is lower purchase cost.

Hard disk drives often use 15 to 30 watts and the controllers add several more watts. The newest disk drives of the IDE type take only 2 watts. Try to do without a hard disk drive if you are a low power fanatic. Sadly, many programs absolutely require a hard disk drive.

Other components in the box are harder to change out for existing systems. The motherboard, video and disk controllers must be matched to other components. Here is another case when older standards implemented with new technology result in dramatic power reductions and reduced costs as well. XT style motherboards now run 3 times faster than the original. High speed 286 and 386SX boards are good choices for faster requirements. True 386 and 486 machines are expensive and overkill for most applications.

Wrapping up

Ac computers may be the way to go for many of you. The purchase is lower, finding parts is easier, and no power supply modifications are necessary. The secret is to lower the power consumption from the typical 400 watts down to about 40 watts. This allows use of the smallest, cheapest inverter.

Access

John C. Osborne, AirCastle Enterprises, 15926 Northville Road, Plymouth, Michigan 48170, 313-348-7135.

Battery To Inverter Circuit Resistance

David W. Doty

It is possible to install code-required safety equipment on low voltage systems without excessive voltage loss. I will use my own photovoltaic system as an example.

The System

My photovoltaic system consists of 8 Hoxan H-4810 modules, 8 Trojan L-16 batteries, a Trace C-30A charge controller and a Trace 2012 SB inverter. The L-16 batteries are wired in series-parallel to produce a bank rated at 12 volts, 1400 amp-hours. The parallel sets of batteries are bussed together with copper buss bar (1.5" x .25") rated for 300 amps. Two parallel 1/0 welding cables (#1 in the diagram) connect the positive battery terminal to a fused disconnect switch (#2 &#3). Another pair of parallel 1/0 welding cables (#5) connect the negative battery terminal to a 500 amp, 100 millivolt shunt. The shunt (#6) is used for metering and also acts as a common point to connect all negative leads. These two sets of main battery cables are each approximately 9 feet long.

The Big Switch

The fused disconnect I am using is a three pole Square D model #H-364. It is rated at 200 amps, 600 VAC. No, this switch is not UL listed for D.C. It does, however, have a fast make & break switch and should not pose any problem at low (12 or 24) D.C. voltages. I have bussed the three poles on the line side of the disconnect switch together with copper bar. This provides me with three separately fused points for my positive wires. The first pole is fused at 200 amps using a Reliance KOS 200 fuse. This fuse is rated at 100,000 amps, 600 volts A.C. interrupting current. This feeds the Trace 2012 inverter thru a 5 foot length of 3/0 welding cable (#4). The negative lead from the inverter is connected with an equal length of 3/0 cable (#7) to the shunt. All cables are terminated with copper lugs. These lugs are carefully soldered on and then protected with sealant filled heat shrink tubing. The second pole of the disconnect is not used at this time. The third pole is fused at 125 amps and connected to an auxiliary 12 volt generator, a D.C. load center, and the photovoltaic charging circuit.

Component Resistance

To determine the actual resistance of the various components in my system, I connected the Trace inverter to utility power and adjusted the battery charger to 105 amps. I then measured the voltage drop across the individual components with a Fluke model 23 digital meter set to the 300 millivolt range. It was then a simple matter to calculate the resistance of the components using Ohms' law, R=E/I. The results are shown in the table below. I have also calculated power (watts) lost through each portion of the circuit at a current draw of 105 amps. As you can see from the table, the power lost through the disconnect switch and fuse adds up to only 6.03 watts at the 105 amp load. This is a small price to pay for a safe system. The pie chart shows the percentage of the total power lost through each component of my system.

Short Circuit Current

Another point I would like to make concerns available short circuit current from low voltage battery based systems. The Trojan L-16 battery is rated at 1550 cold cranking amps. My system would therefore be able to provide 6200 amps of current (1550 x 4 pairs of batteries) at 12 volts. This is cranking current, not short circuit current. Short circuit current would be even greater. The total resistance of the system components (.002429 Ω) would limit this current to a lower value. A direct short circuit at the inverter input terminals would be limited to 4940 amps. This can be calculated using Ohms' law, I=E/R, or I=12/.002429. This means that a protective fuse or circuit breaker with an interrupting rating of 10,000 amps D.C. would be more then adequate for my system.

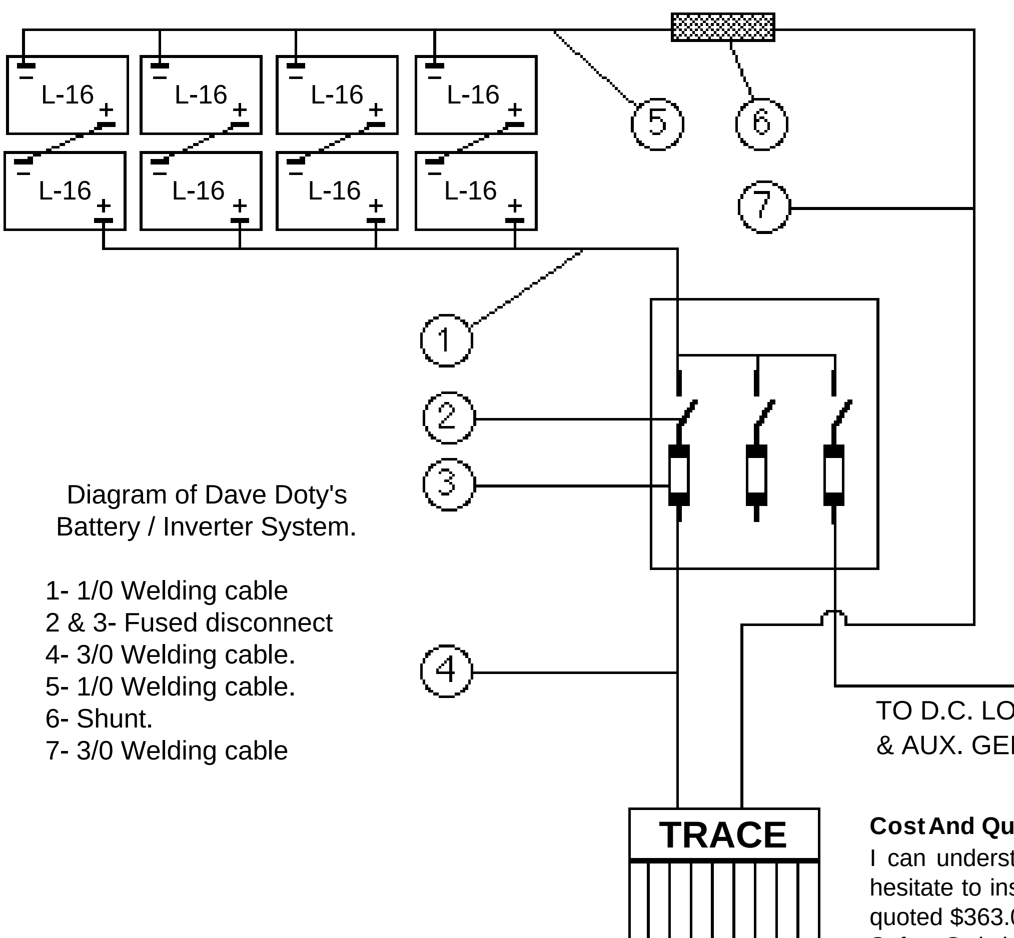


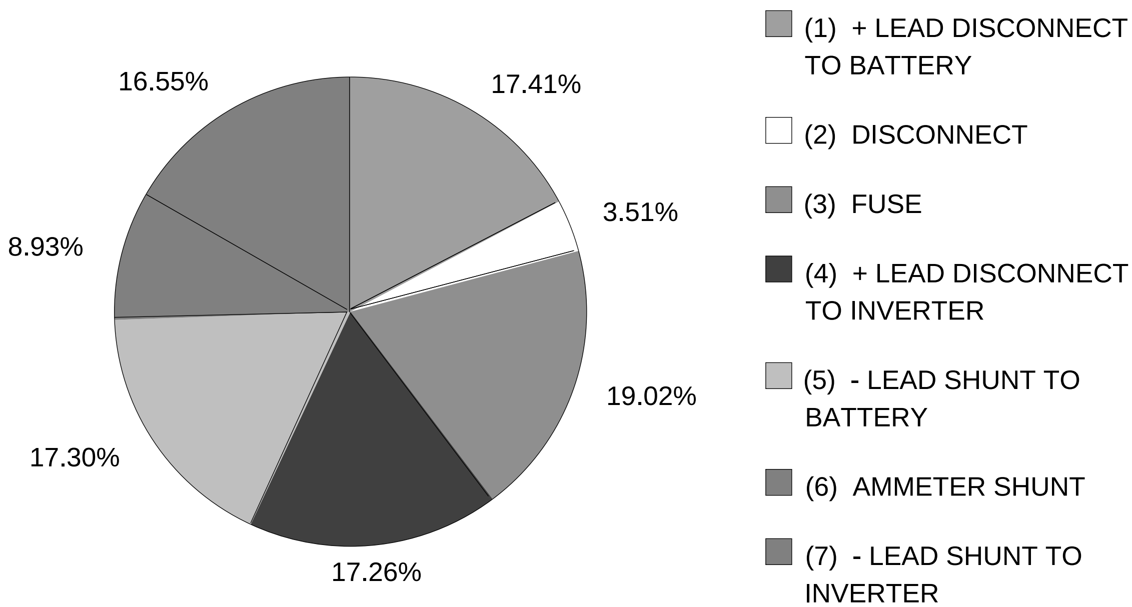
Diagram of Dave Doty's Battery / Inverter System.

1- 1/0 Welding cable
2 & 3- Fused disconnect
4- 3/0 Welding cable.
5- 1/0 Welding cable.
6- Shunt.
7- 3/0 Welding cable

Cost And Quality

I can understand, due to the initial cost, why people might hesitate to install this vital piece of safety equipment. I was quoted $363.00 (list price $481.00) for the Square D #H-364 Safety Switch from a major electrical supply house. But you

CIRCUIT ELEMENT	VOLTAGE DROP @ 105 AMPS	RESISTANCE (OHMS)	POWER LOST (WATTS)
(1) + LEAD DISCONNECT TO BATTERY	0.0444	0.000423	4.66
(2) DISCONNECT	0.0090	0.000086	0.94
(3) FUSE	0.0485	0.000462	5.09
(4) + LEAD DISCONNECT TO INVERTER	0.0440	0.000419	4.62
(5) - LEAD SHUNT TO BATTERY	0.0441	0.000420	4.63
(6) AMMETER SHUNT	0.0228	0.000217	2.39
(7) - LEAD SHUNT TO INVERTER	0.0422	0.000402	4.43
TOTAL CIRCUIT	0.2550	0.002429	26.77



get what you pay for. This is a high quality piece of electrical gear. It has the large solid copper switch components and high pressure fuse clips necessary for low loss. The quality of electrical equipment can vary greatly between manufacturers. Care must be taken when choosing electrical equipment.

Conclusion

I'll be honest, I didn't install a safety switch in my own system until I was able to scrounge a used one for free. This is a poor excuse, though, and you should be prepared to face the consequences if you opt to take this route. I have personally witnessed several total melt downs of electrical equipment in my past 14+ years as an electrician. While most of these incidences involved high voltage high power systems, the same things can happen in low voltage systems. A co-worker of mine once dropped a 9/16" wrench across the battery terminals of a 36 volt, 220 amp/hour battery bank. This wrench turned cherry red in a matter of seconds and then, luckily, burned in half before further damage occurred. The destructive power of wayward electricity is truly astonishing. Disconnect switches and fuses are Code required for good reason!

Access

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☐	☐	**Water power generator**	☐	☐	**Inverter**
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MEET THE CODE, MAXIMIZE PERFORMANCE, AND KEEP COSTS DOWN

John Wiles

In the last installment of Code Corner, the reasons for applying the National Electric Code (NEC) to photovoltaic power systems were discussed. Some of the whys and hows for those who have decided to install safe PV systems which comply with the Code will now be reviewed.

AC Power Systems vs DC Power Systems

The NEC does not establish requirements for protecting components such as PV modules, charge controllers, inverters, and various appliances connected as loads. The Code assumes that these devices are designed to protect themselves and the user from electrical shock and fire. When a component device has been tested and listed by Underwriters Laboratories (UL), it will meet numerous standards that result in reasonably safe operation and yield a device that can be connected to other UL listed components without problems. This is the story of the alternating current power systems that are in use every day -- UL listed wire, UL listed outlets, UL listed appliances, UL listed load centers, etc. All systems work together and can be safely connected with only a little training and experience because the interface standards between each component are established and controlled by one agency -- UL.

Unfortunately, in PV power systems there are few UL listed products and therefore the standards and the interface control that UL listing implies do not exist. The National Electric Code is the only recourse available for designing and installing PV systems with some degree of safety.

Overcurrent Protection for Conductors, Not Equipment

The system installed in accordance with the Code will have every conductor protected with an overcurrent device. If any conductor is shorted to a conductor of the opposite polarity at any place in the system, an overcurrent device will open and prevent any damage. Fuses and circuit breakers inside inverters and charge controllers generally do not protect the wiring, but are designed to protect the device itself.

For this reason, overcurrent devices are needed between the battery and the PV array to protect the array wiring; between the battery and the inverter to protect that wiring; and between the battery and the loads to protect the load wiring.

Disconnects For Safety

In order to adjust and service the various electronic components in a PV power system, the NEC requires that disconnects be used to cut off voltage/current to those same devices requiring wiring overcurrent protection.

This presents a strong rational for using dc-rated, UL listed circuit breakers for both the disconnect function and the overcurrent protection. As mentioned previously, Square D residential ac circuit breakers can be used on systems with open circuit voltages up to 48 volts (12 and 24 volt systems) and current requirements up to 70 amps. This would include systems with 12-volt, 600-watt inverters. Square D products have the advantages of widespread availability and factory manufactured load centers to hold the breakers. If higher currents are needed, Heinemann or Airpax circuit breakers can be used, but they are special order items and custom enclosures must be used. Airpax has dc rated, UL listed circuit breakers with a voltage rating up to 125 volts dc and current ratings up to 100 amps. Heinemann has UL listed breakers at 125 volts and higher with current ratings up to 700 amps! Caution must be exercised when using UL recognized breakers as they are not approved for branch circuit protection and generally have low short-circuit interrupt capabilities.

Separate The Charge and Discharge Circuits

In previous Code Corner discussions, it was noted that the charging and discharging conductors from the battery should be separate circuits to prevent open circuit PV voltages from being inadvertently applied to the load. A circuit from the battery to the charge controller/PV source circuits with a breaker in it is needed. Another breaker would be needed in a circuit between the battery and the dc load circuits and possibly a third between the battery and the inverter if any. Here is the reasoning for three circuits.

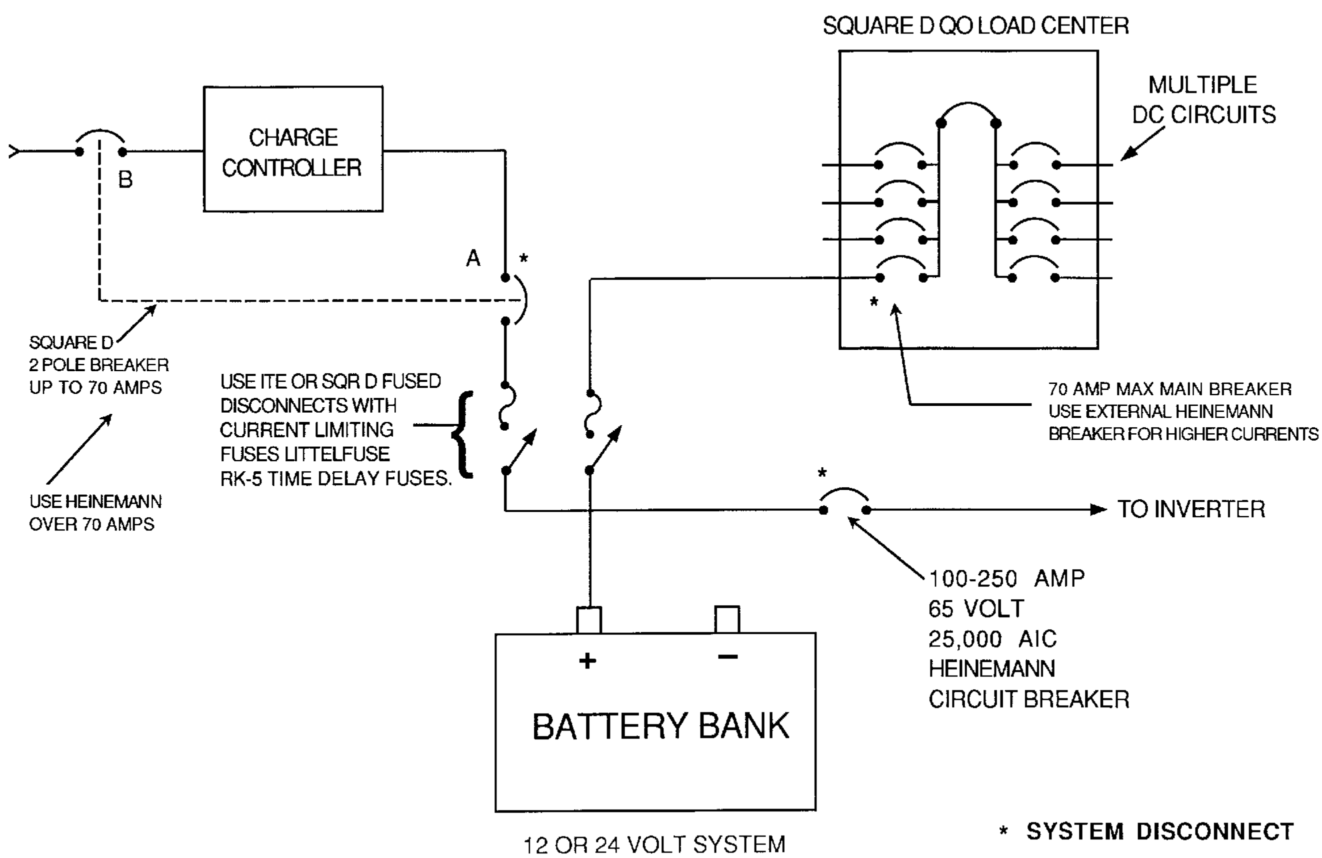
Short Circuits Can Be Destructive

The batteries can deliver extremely high levels of current under short-circuit conditions. The levels of current are so high that standard fuses and circuit breakers will be destroyed when subjected to these currents and there is danger in the flying shrapnel released when they blow apart. For this reason, it is important to use current limiting fuses near the battery in the circuit to the charge controller and in the circuit to the dc loads. These current limiting fuses will protect the circuit breakers used in the PV source circuits and the multiple circuit breakers used in the dc load center.

Since the inverter may draw large currents and is on a separate circuit, a special circuit breaker can be used which has the interrupt capability of 25,000 amps at 65 volts dc. This breaker does not have to be protected by a current limiting fuse and by holding the number of devices in this circuit to a minimum, the inverter performance is maximized. Heinemann can supply these breakers with a UL listing up to 110 amps and a factory listing up to 250 amps at 65 volts dc. In fact, if all of the circuits were protected by circuit breakers with this high interrupt rating, there would be no need for the current limiting fuses -- but the cost would be much higher than using Square D QO breakers where appropriate in the other circuits.

The figure below shows how the proper components might be connected for lowest cost and maximum performance. The two-pole breaker connected before and after the charge controller needs to be a two-pole unit only if the controller is sensitive to the power connection sequence or should not be connected to the batteries or the PV array alone. The breaker in front of the controller is needed to disconnect the PV input. The controller

A LOW COST, HIGH CURRENT PV DISCONNECT SYSTEM
MEETING NEC REQUIREMENTS



could be isolated from the battery (for servicing) with the fuse disconnect switch if the second pole of the two-pole circuit breaker is not used. The system disconnects must be grouped together so it is probably best to use the two-pole unit because the fuse disconnect switch should be located close to the battery.

In this 12 or 24 volt system, Square D QO breakers up to 70 amps could be used in all locations except between the battery and the inverter. This location requires a breaker that can handle currents higher than 70 amps and could be a Heinemann CD (up to 110 amps) or GJ (up to 250 amps) breaker. A custom box would be needed.

The circuit configuration shown meets the requirements of the NEC, provides protection from accidental over voltage on the loads, maximizes inverter performance and holds costs to a minimum. In the next Code Corner, load circuits will be discussed.

Access

John Wiles, Southwest Region Experiment Station, PO Box 30001/Dept 3SOL,, Las Cruces, NM 88003 505-646-6105.

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ALTERNATIVES TO FOSSIL FUELED ENGINE/GENERATORS

Clifford W. Mossberg

For most of us who live in secluded areas and who employ alternative energy technologies to provide us with a contemporary standard of living, looking for more efficient alternatives is second nature. Most of us have wondered about an alternative to the use of fossil-fueled engine/generators to back up our more desirable energy sources.

Photovoltaics and wind energy are intermittent or diffuse technologies which require storage to be effective and are limited in output. Hydro power is site specific and will not be available in many places. Alternative energy generation also costs a lot of money initially and the temptation to go with the cheapest and sometimes only affordable power source is strong. Usually that is a fuel driven engine/generator. There are lots of reasons to use a "light plant", but sooner or later the moment of truth comes: These things are noxious, noisy, take more maintenance than a new born baby, and eat more than a teenager. "Isn't there something else!?"

Yes there is. The advantage to a "light plant" is that by paying the price we are able to create energy in large quantities and at our discretion using easily obtainable and conveniently transported fuel. We are not at the whim of wind, sun and water. So any replacement technology must have, at a minimum, this element of discretionary use.

Steam Power

Historically one of the earliest alternatives to fossil fuels is a wood fired boiler producing steam which powers an engine driving a generator. I've noticed interest in this recently among letters from Home Power readers. I would like to share some perspectives on steam power and its alternatives.

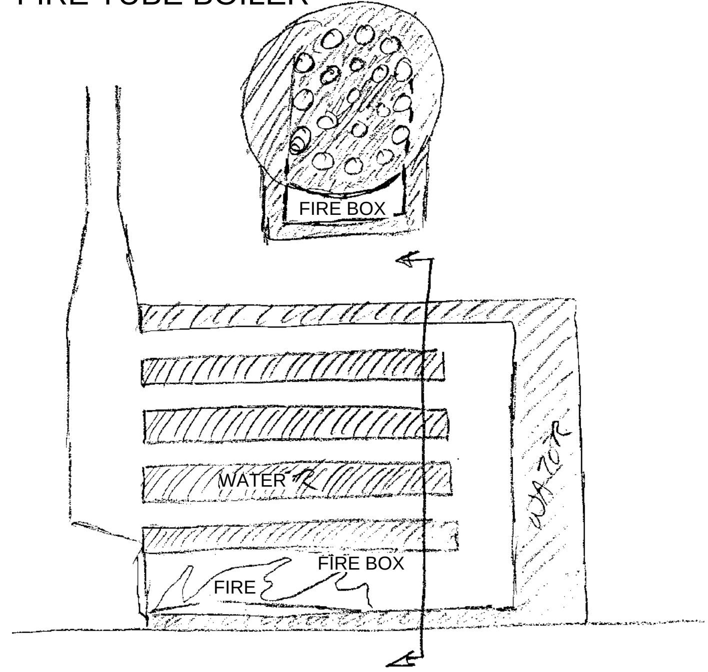
First the good news: Steam CAN be produced from wood; allowing us to use Ma Nature to produce and store our energy for us in our own back forty. This, unfortunately is about the only advantage. The bad news is that steam power has all the disadvantages of an engine/generator and several more all its own. Ma Nature may provide the fuel but we, the user, must "condition" it. The wood must be chopped and carried, cured, split, and fed, just as for any wood stove. Ashes must be handled and hauled. The entire installation requires constant babysitting while it is running -- no walking away from this thing to do the wash! But the real kicker is the inherent danger in steam.

Steam occupies about 1200 times the volume of water at atmospheric pressure (known as "gage" pressure) -- that's ONE THOUSAND TWO HUNDRED TIMES! Producing steam requires heating water to above boiling temperature under pressure. Water boils at 212° F. at sea level. By pressurizing the boiler it is possible to raise the boiling temperature of water much higher. At a pressure of 52 psi gage the boiling temperature is 300°, at 120 psi gage it is 350°. Elevating steam temperature like this HAS to be done to use the the generated steam for any useful work otherwise the steam would condense in the supply lines or inside the cylinder of the steam engine itself. Typical working limits for a small simple "home style" boiler are in the range of those given above.

Fire Tube Boiler

There are two basic kinds of boilers: The first is the FIRE TUBE boiler where the water is heated in a large pressurized tank. To increase the surface area so that heat may be transferred to the water more efficiently there are tubes passing thru the boiler carrying hot flue gases. Essentially these tubes are multiple smoke stacks which run from the fire box through the water before exhausting up a chimney. This type of boiler can hold a significant amount of water.

FIRE TUBE BOILER



Water Tube Boiler

The second type of boiler is a WATER TUBE type. In this unit water is carried through the fire box in pipes. Steam is produced in these pipes and goes to the point of use. This type of boiler has much less water heated and under pressure at a given time.

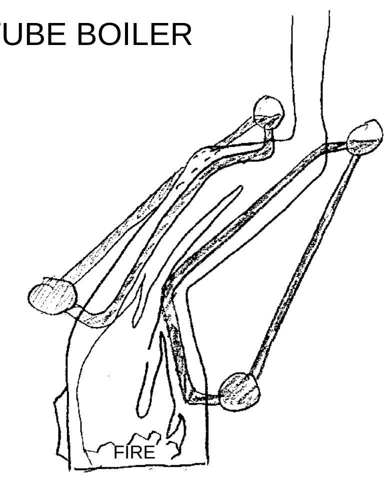
Why worry about the amount of heated and pressurized water? Picture a very small boiler, maybe the size of a fifty-five gallon drum. Rough dimensions of one of these drums is around 24 inches in diameter by about 36 inches long; about 9 1/2 cubic feet of water at 70 pounds per square inch (all pressures are given as "gage" here, which means the atmospheric pressure of about 15 psi is subtracted from the "absolute" pressure reading) and 316° F.

What happens if the boiler springs a leak? Pressure immediately falls. Since there is less pressure on the heated water it immediately starts to boil. As the water boils it produces steam which raises the pressure on the water and inhibits boiling. This condition normally exists in a boiler and produces a controlled reaction. The "leak" is the boiler steam outlet pipe.

But what happens if there is an uncontrolled leak in the boiler such as equipment failure might produce? As pressure drops and water starts to boil there is no restriction to stabilize the pressure and ALL the water can immediately flash into steam. In our example if you start out with 9 1/2 cubic feet of superheated water and reduce the pressure to zero you almost instantaneously have 1200 times 9 1/2 cubic feet, equal in volume to a single story house measuring about 35 by 40 feet. You suddenly have 11,400 cubic feet of steam in a 9 1/2 cubic foot pot and a real -- but short lived -- problem; a massive boiler explosion.

At the core of this explosion is superheated steam at 316°. If the shrapnel and concussion is daunting enough, this 316° steam will instantly cook any flesh it comes in contact with and can literally strip flesh off the bone. Does the average small homesteader want to play dice with this process? (The hypothetical boiler in our example has a total internal working force of about 125 tons applied to it!)

WATER TUBE BOILER



A water tube boiler is more benign. It may only result in an explosive steam volume of one or two "rooms" in the "house" in the example. Therefore a water tube boiler is the preferred design for anyone getting serious about steam. Failure of a water tube boiler probably won't take out City Hall, but it would not be comforting to those in the vicinity.

So why not just opt for a water tube boiler and get on with it? Economics. A fire tube boiler can be fabricated from a cylindrical tank with straight tubes running through it from end to end. A water tube boiler is fabricated as a fire box with many small tubes with complicated bends in them welded inside. There is a lot more precise design, welding, and fabrication involved with a water tube boiler.

Then there is the fact that ALL boilers manufactured or used in the United States must be built to rigid specifications and tested in accordance with regulation and prescribed procedure; not just initially but throughout their installed life. Any boiler is potentially dangerous and expensive.

If you are willing to spend money to acquire a working boiler and operate it what do you have? Let's look at efficiency:

The traditional gasoline engine can be used as a baseline that we are familiar with. It is considered to be about 28% efficient. A diesel engine is considered to be about 32% efficient. This efficiency is a measure of the engine's ability to turn heat energy in fuel into useful work and the figures I've given represent an average of a range of values. A better way of thinking of efficiency is that 72% of the heat developed by gasoline burned in a gasoline engine is wasted; or about seven out of every ten gallons of gas you burn goes to heat the air, either through the radiator, radiation from the engine, or out the tailpipe. How does steam compare?

A typical single acting single cylinder steam engine (the kind most of us might easily acquire) runs from about 7% to 12% efficiency. A high performance double acting multi-cylinder unit might run about 15% to 17% efficiency. A well insulated unit with a vacuum condenser might push that up as high as 22% if you were very lucky. Even were you to go to a very sophisticated steam turbine installation -- totally out of sight financially for most of us -- the efficiency would only be pushed up to about 26%; the lower end of gasoline engine technology. Bear in mind that YOU will bear the direct burden of this inefficiency right on your back. Only 7% of the energy in the firewood you painstakingly lugged out of the woodlot will turn into energy you can use to generate electricity. This doesn't factor in any environmental damage.

I haven't said anything yet about your time. The typical small steam installation will require constant attention to operate. Automatic controls do not adapt well to burning a non-uniform fuel like logwood and are too expensive and complex to find their way into small installations. You will have to hover over this unit to feed fuel, monitor boiler pressure, check feed water, oil equipment, etc. The operator is apt to become the exclusive servant of the machine when it is powered up.

Now that I have painted this bleak picture let's ask if there's any alternative to steam as a replacement for the family "light plant"? YES! The surprising answer is that a conventional gasoline or diesel driven engine/generator set can be combined with wood gas technology to do the job. While it has drawbacks of its own, this marriage is much cheaper and safer than steam.

Wood Gasification Basics

Wood gasification is also called producer gas generation and destructive distillation. The essence of the process is the production of flammable gas products from the heating of wood. Carbon monoxide, methyl gas, methane, hydrogen, hydrocarbon gases, and other assorted components, in different proportions, can be obtained by heating or burning wood products in an isolated or oxygen poor environment. This is done by burning wood in a burner which restricts combustion air intake so that the complete burning of the fuel cannot occur. A related process is the heating of wood in a closed vessel using an outside heat source. Each process produces different products.

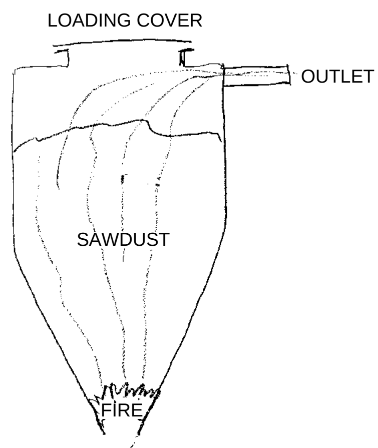
If wood were given all the oxygen it needs to burn cleanly the by-products of the combustion would be carbon dioxide, water, some small amount of ash, (to account for the inorganic components of wood) and heat. This is the type of burning we strive for in wood stoves.

Once burning begins though it is possible to restrict the air to the fuel and still have the combustion process continue. Lack of sufficient oxygen caused by restricted combustion air will cause partial combustion. In full combustion of a hydrocarbon (wood is

basically a hydrocarbon) oxygen will combine with the carbon in the ratio of two atoms to each carbon atom. It combines with the hydrogen in the ratio of two atoms of hydrogen to one of oxygen. This produces CO_2 (carbon dioxide) and H_2O (water). Restrict the air to combustion and the heat will still allow combustion to continue, but imperfectly. In this restricted combustion one atom of oxygen will combine with one atom of carbon, while the hydrogen will sometimes combine with oxygen and sometimes not combine with anything. This produces carbon monoxide, (CO) (the same gas as car exhaust and for the same reason) water (H_2O), and hydrogen gas (H). It will also produce a lot of other compounds and elements such as carbon, (C) which is smoke.

Combustion of wood is a bootstrap process. The heat from combustion breaks down the chemical bonds between the complex hydrocarbons found in wood (or any other hydrocarbon fuel) while the combination of the resultant carbon and hydrogen with oxygen -- combustion -- produces the heat. Thus the process drives itself. If the air is restricted to combustion the process will still produce enough heat to break down the the wood but the products of this inhibited combustion will be carbon monoxide and hydrogen, fuel gases which have the potential to continue the combustion reaction and release heat since they are not completely burned yet. (The other products of incomplete combustion, predominately carbon dioxide and water, are products of complete combustion and can be carried no further.) Thus it is a simple technological step to produce a gaseous fuel from solid wood. Where wood is bulky to handle, a fuel like wood gas (producer gas) is convenient and can be burned in various existing devices, not the least of which is the internal combustion engine. A properly designed burner combining wood and air is one relatively safe way of doing this.

CRUDE WOOD GAS GENERATOR



Another path to a similar result is to heat wood in a closed container until it is hot enough for the chemical bonds holding the hydrogen and carbon together to break. This is destructive distillation, a quite different process from that of combustion since no outside oxygen is introduced. You might think that such a device would produce only hydrogen gas and carbon But that is only because I have kept this explanation oversimplified for clarity. The products of this process will depend on the make up of the wood and the temperature it is heated to. All wood contains some water and this can be anywhere from about 7% to 50% or higher, so this water is available to play a part in the destructive distillation process. Wood also contains many other wild and wonderful chemicals, From alkaloid poisons to minerals. These also become part of the process. They can be assets or great liabilities.

As a general concept, destructive distillation of wood will produce methane gas, methyl gas, hydrogen, carbon dioxide, carbon monoxide, wood alcohol, carbon, water, and a lot of other things in small quantities. Methane gas might make up as much as 75% of such a mixture.

Methane is a simple hydrocarbon gas which occurs in natural gas and can also be obtained from anaerobic bacterial decomposition as "bio-gas" or "swamp gas". It has high heat value and is simple to handle.

Methyl gas is very closely related to methyl alcohol (wood alcohol) and can be burned directly or converted into methyl alcohol (methanol), a high quality liquid fuel suitable for use in internal combustion engines with very small modification.

It's obvious that both of these routes to the production of wood gas, by incomplete combustion or by destructive distillation, will produce an easily handled fuel that can be used as a direct replacement for fossil fuel gases (natural gas or liquified petroleum gases such as propane or butane). It can be handled by the same devices that regulate natural gas and it will work in burners or as a fuel for internal combustion engines with some very important cautions.

Producer Gas Generators

How do you achieve this? Let's start with the combustion process hardware first: The simplest device I know of is a tank shaped like an inverted cone (a funnel). A hole at the top which can be sealed allows the user to load sawdust into the tank. There is an outlet at the top to draw the wood gas off. At the bottom the point of the "funnel" is opened and this is where the burning takes place. Once loaded (the natural pack of the sawdust will keep it from falling out the bottom) the sawdust is lit from the bottom using a device such as a propane torch. The sawdust smolders away. The combustion is maintained by a source of vacuum applied to the outlet at the top, such as a squirrel cage blower or an internal combustion engine. Smoke is drawn up through the porous sawdust, being partly filtered in the process, and exits the burner at the top where it goes on to be further conditioned and filtered. The vacuum also draws air in to support the fire. This burner is crude and uncontrollable, especially as combustion nears the top of the sawdust pile. This can happen rapidly since there is no control to assure that the sawdust burns evenly. "Leads" of fire can form in the sawdust reaching toward the top surface. Once the fire breaks through the top of the sawdust the vacuum applied to the burner will pull large amounts of air in supporting full combustion and leaning out the value of the producer gas as a fuel. This process depends on the poor porosity of the sawdust to control the combustion air so chunk wood cannot be used since its much greater porosity would allow too much air in and you would achieve full combustion at very high temperatures rather than the smouldering and the the partial combustion you want. Such a burner is unsatisfactory for prolonged gas generation but it is cheap to build and it will work with a lot of fiddling.

For prolonged trouble free operation of a wood gas generator the burner unit must have more complete control of the combustion air and the fuel feed. There are various ways to do this. For example, if the point of our original funnel shaped burner is completely enclosed then control over the air entering the burner can be achieved. This configuration will successfully burn much larger

pieces of wood. One of the most widely known burners was developed by Mother Earth News magazine. They produced a complete set of plans for their burner and featured its construction and evaluation in several issues of their magazine. At the end of this article I have listed sources of information and/or hardware for several of the concepts I have written about.

Destructive Distillation Units

If the type of wood gas you would like to produce is to be obtained by destructive distillation then all you need is a canister about the size of a 55 gallon drum that can be loaded with wood and sealed air tight. It must also have an outlet pipe and a source of heat which can be applied to it from the outside. A simple way to do this would be to just build a wood bonfire under the canister. While this has the advantage of being "quick and dirty" it is the equivalent of the simple sawdust burner I described above. It allows little control and requires a lot of time and fussing to make anything work.

The use of a fossil fuel to heat the wood gives good control over the temperature of distillation but defeats the purpose of producing a fuel from wood. An ideal solution to this control problem is to use a combustion type wood gas generator to produce fuel gas, which is then burned to achieve destructive distillation, which produces a higher heat content fuel; a fuel that can then be liquified into methanol.

It is also desirable to mount the canister in such a way that it can be rotated while it is being heated so that the contents inside are evenly "cooked".

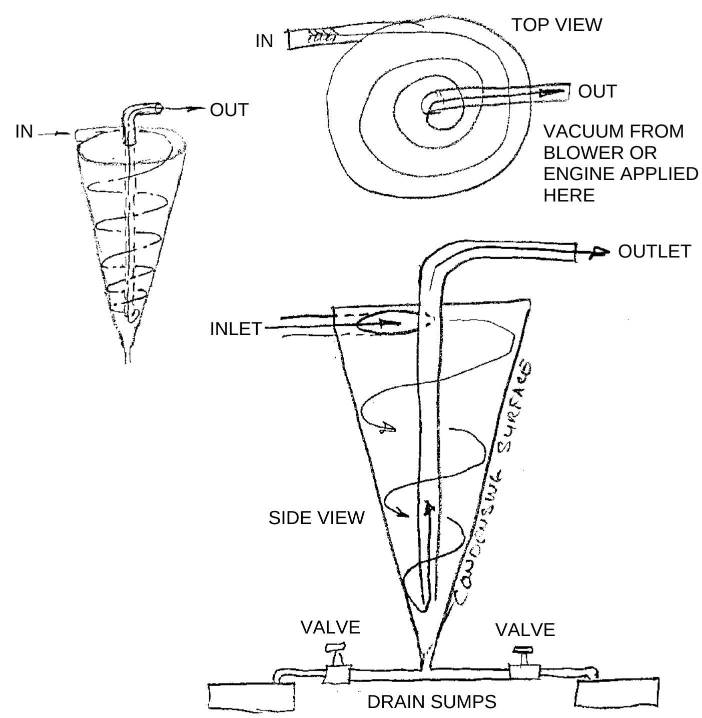
Conditioning And Filtration

However you produce the wood gas you are certainly not home free when your fuel exits your burner. Far from being the nice clean chemical reactions I've used for simplicity, the fuel gas you will actually produce will contain ash, gum, heat, water, creosote, acids, and a lot of other weird things which will render any device you try to burn the fuel in dead on arrival. The fuel must be conditioned and filtered before it can be used.

Probably the best first step to achieve gas conditioning is a cyclone separator to get rid of water and particulate matter. This device is again an inverted cone but the bottom is sealed. After the contaminated fuel gas leaves the burner unit it enters the top on a tangent to the circumference of the side. The exit for the fuel is a pipe which runs up the center of this cone from just above the point at the bottom. Gas coming into the cyclone separator enters with some velocity. Because it has weight and therefore inertia it tries to continue in a straight line even though the sides of the cone are curved. To exit the cone the gas would have to turn 90° toward the bottom and then 180° up the exit pipe if it could take the shortest path. However under the influence of its own inertia the dirty fuel gas is held against the curved outside wall of the cone, where it takes a circular path toward the bottom and the exit pipe. It circles around and around this wall, all the time moving in tighter and tighter circles toward the point on the bottom, thus speeding up its velocity as the circles get smaller nearer the point. The fuel gas is spinning quite fast near the exit pipe. This rotary gas flow is where the separator gets its name.

Within this stream of rapidly spinning gas the ash and water vapor, weighing more than the fuel gas, are thrown outward against the walls of the separator by centrifugal force. When the heavier components in the fuel gas come into contact with the relatively cool sides of the separator the water condenses, wetting the inside of the separator down and flowing downward to a drain at the bottom. Ash and particulate matter are also thrown out against the

CYCLONE SEPARATOR



now wet walls where they get washed out of the gas stream by the condensing liquid. All of this gunk winds up running out the bottom of the separator and into a holding tank, which can be drained at intervals.

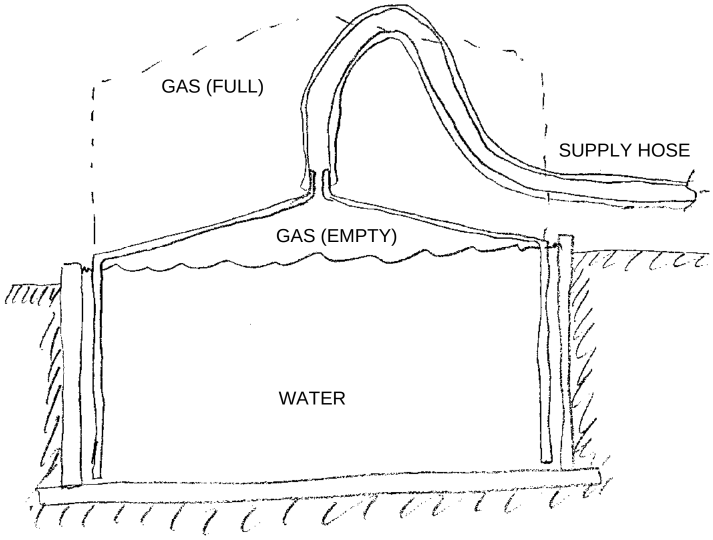
To help the water condense out of the gas stream the walls of the cyclone separator may be cooled by water or an air stream to raise the efficiency of the condensation and scrubbing process.

Upon its exit from the cyclone separator the fuel gas will have to be cooled further. A simple way to do this is to place a vehicle radiator into the gas flow and draw the fuel gas through this. In a perfect world there wouldn't be any water left in the fuel gas after it left the cyclone separator. Unfortunately there is apt to be quite a bit of uncondensed water vapor still left in the hot fuel gas as it enters the gas cooler. As the gas cools the water vapor will condense out further. It may be necessary to use multiple stages to completely cool the fuel gas. That is you may have to use more than one radiator, with the outlet of one connected to the inlet of the next, and so on. Cooling air can be blown through each radiator by an electric cooling fan and each radiator will need a sealed drain canister to carry off condensed liquid.

Once the cool dry fuel gas leaves the cooler it is ready for the last stage of conditioning. It must be well filtered to keep fine ash and particulate matter from being carried into the engine or burner which the gas will be used in.

An alternative to immediate use of fuel gas is storage. The gas can be stored at low pressures -- 3 to 5 psi-- in a simple tank of the type developed to store biogas from methane/solid waste digester. This is an open tank placed upside down in water. When empty, the tank sinks in the water but as gas is forced in the tank rises out of the water. The weight of the tank can be augmented or

LOW PRESSURE GAS STORAGE TANK WITH WATER SEAL



counterbalanced to control the pressure of the gas inside. Fuel gas is pulled from the gas generator by a simple centrifugal bower, which forces it through the conditioning stages and into the storage tank under pressure. It is desirable (but not necessary) to have a storage tank even if the gas is to be immediately used as fuel. Such a reservoir maintains a buffer supply of gas to even out any fluctuations in supply and provides an even, controllable supply of pressure to the end device. It also acts as a cooler and a sink for any impurities which remain in the fuel gas after conditioning. Such a storage tank could pay for itself by saving money on conditioning the fuel gas since contaminants will cool, condense, and settle out in the storage tank and water seal. Two tanks, used alternately, may reduce the need to condition the gas, requiring only the use of the cyclone separator. In this arrangement one tank can be filled and cooling off while the user device is run from the second tank.

If your choice is to produce methane and methyl gas rather than producer gas, then the conditioning process will not be so demanding. You will not have a lot of ash and carbon to deal with. The products of destructive distillation will exit the generator canister under their own pressure. If a blower is used to fill a gas storage tank it should be placed after the gas cooling stages are held at a partial vacuum as condensation occurs, this will improve their efficiency. The final particulate filter can be eliminated, especially if gas storage tanks are utilized.

If your goal is to produce methyl alcohol (methanol) then you will have to catalyze the methyl gas and methane into liquid alcohol. In addition, you will not want to use a cyclone separator since the condensed liquid contains the methanol you are seeking. Gas coming from the generator canister will pass through a catalyzer unit. The alcohol vapor produced by catalyzation is then routed to the gas cooling stages which condense it to liquid methanol. In this case the drains from the cooler carry off the raw methanol distillate rather than waste condensate. This raw methanol will undoubtably require further distillation to purify it and extract excess water.

Catalyzing the methane and methyl gas can be accomplished crudely but simply. The gas which comes out of the generator canister is routed through a copper pipe with a copper "Chore Girl" pot scrubber inserted in it. A one inch copper pipe about twenty feet long attached directly to the generator outlet and having the "Chore Girl" inserted into it loosely should do the job. The inlet of the pipe should be above the outlet so that any methanol condensing in the catalyzer can drain out. Insulating the catalyzer to keep the temperature up will help greatly. Soft copper pipe formed into a large coil makes a relatively compact catalyzer. The outlet from the catalyzer is attached to the cooling (condenser) stages.

I've suggested a copper catalyst (the Chore Girl) because of its availability and cost but it is not the most efficient catalyst. It may well be that a platinum catalyst would be much more efficient but a custom built platinum catalyst would be very expensive. With the common availability of platinum based automotive catalytic converters, use of one of these converters may be a better alternative than what I have described. I have no hands-on knowledge of that though.

Hydrogen Fuel

Another alternative to steam is the use of on-site generated hydrogen as a fuel for an internal combustion engine. Hydrogen makes a very high quality fuel because it burns so cleanly. The only product of idealized hydrogen combustion is water and heat.

The use of hydrogen as a motor fuel is very much in the experimental stage right now. Commercial supply of hydrogen just is not commonly available in quantity. Neither is there a convenient technology for storing it in any quantity. Technologies such as metal hydride storage and liquid hydrogen are beyond the scope of this article and beyond the scope of most users. On-site generation of hydrogen is a viable alternative however.

In the past small scale "home" generation of hydrogen gas was commonly done by electrolysis of water. If a tank is fabricated in a "U" shape with a cathode in one leg and an anode in the other a current can be passed through the water. The electrical energy will disassociate the atoms of hydrogen and oxygen in the water, with each component gas collecting in a different leg of the tank where they can be drawn off in pure form. Using the right combination of pressure, voltage, and current this can be done fairly efficiently. The electrical supply can be from an alternative energy source.

Recently, however, there has been work done on a gas generator which can produce large quantities of hydrogen simply and efficiently using a device similar to a wire feed (MIG) welder. (See Hydrogen Fuel Breakthrough With On-demand Gas Generator, Automotive Engineering, August 1985, Volume 93, Number 8, Page 81) An aluminum wire charged with electricity is fed under water to a rotating drum. The arc from the electrical contact causes the aluminum in the wire to combine with the oxygen in the water. The reaction produces hydrogen and oxygen gas and a slurry of aluminum oxide, which settles to the bottom of the tank. This generator is small, portable, and low tech, and can easily be incorporated into a vehicle.

This technology is very promising since either in a vehicle or in a stationary unit the gas generator can be run by a battery which is charged by alternative energy methods. It is obvious that it can also be charged by the device it supplies, such as an engine/generator unit or a hydrogen fuel cell. This technology also provides a viable alternative to an all-electric vehicle since it takes much less stored battery energy to produce the hydrogen fuel from

water than it would to actually power the vehicle entirely with battery storage. This has great potential but I have no hands-on experience with it as yet.

Safety

It's important to cover some of the safety considerations of fuel gas, alcohol, and hydrogen gas:

Unlike steam power there is no storage of massive amounts of latent energy in a wood gas generator of either type. Producer gas generators run under a modest vacuum, while destructive distillation proceeds under relatively low pressure. Obviously all the gases are flammable and the usual precautions taken with more common gaseous fuels, such as natural gas and liquid petroleum gases, should be observed. In addition there are considerations specific to these home brewed fuels.

Hydrogen, either by itself or as a component of wood gas fuels, has the smallest and lightest molecule of any element. Consequently it will pass through holes and pores that would be too small for any other gas. Thus hydrogen is very prone to leak, either from poor connections or right through the pores of material used for tanks, hoses and caulking. On the other hand, the "Hindenburg Syndrome" not withstanding, there is actually less danger from leaking hydrogen exploding because it is so light it rises and dissipates readily in the air.

Carbon monoxide is a large component of producer gas and it is deadly. It's not sufficient for anyone overcome by carbon monoxide to just reach fresh air because the monoxide combines with the hemoglobin in blood to render it permanently inert. Blood so affected can no longer carry oxygen to the body and brain. Thus extensive emergency measures must be taken to treat a victim of carbon monoxide poisoning. This means that producer gas generated by a burner is NOT AT ALL suitable for use in stoves, water heaters, gas refrigerators, or any enclosed area where concentrations of the gas might collect if a flame went out. This gas must only be used in VERY well ventilated areas, preferably outside or under a roof with no walls.

Methanol (wood alcohol) is also quite deadly, including the fumes which might be breathed. Methyl alcohol interferes with the function of the nervous system and will cause blindness and death in small quantities if consumed. The process which produces either a gaseous product from destructive distillation, or which is the first step toward production of wood alcohol, can contain methanol as a hot vapor. Therefore it is not actually necessary to consume wood alcohol to be poisoned by it. Breathing methanol vapor from a poorly sealed generator system will have the same deadly effects.

Power Producing Hardware

Before I discuss the hardware to produce power from wood gas I would like to warn you that I will not be writing about some of the newest and most promising techniques for the simple reason I am not qualified. Things like fuel cells, Stirling engines, and hydrogen fuel will be ignored. My original work with wood gas grew from trying to use wood as a cheap, renewable, locally available fuel. It evolved through through steam technology -- which I found too inherently dangerous -- to wood gas, and into methanol as a fuel. My purpose for writing this now is to discourage people from fiddling with steam power because of the tremendous damage that the energy stored in latent heat can do in an equipment failure. So I will concentrate on machinery which can be readily used to turn wood into power.

As I've already mentioned, the fuel gases you can generate from wood can be used as any other gaseous fuel; either burned in an external combustion burner or used as fuel for an internal combustion engine.

Two further considerations are whether the fuel will be used directly as it is produced from the generator or whether the gas will be stored and then used.

First let's briefly discuss the use of fuel gas in an external burner: If you intend to use fuel gas for this purpose I wish to repeat my warning about the deadly nature of producer gas due to its carbon monoxide content. Producer gas is totally unsuitable for domestic indoor gas use. However gas produced through destructive distillation is useful for this purpose. Since it is methane it is similar to natural gas but unlike natural gas it does not have fractions of the heavier petroleum gases such as propane and butane to fortify the heat content. Fuel gas obtained from destructive distillation is a relatively low heat content fuel and therefore requires larger quantities to do the same job. The significance of this is that a burner will have to be designed to flow larger quantities of gas. In some cases you may find regular stove top and oven burners that will work satisfactory since these are usually highly adjustable so that they can burn either dense LP gas or lighter natural gas. The range of this adjustment may include that necessary for wood gas. Since wood gas is close to biogas in nature the user will find useful information on burners in the biogas literature, which is more readily available publicly than that on wood gas.

Gas from destructive distillation will burn very clean, so clean in fact you may not realize it is burning. In daylight the flame will be almost invisible under the right conditions, The user is cautioned to consider this as a safety hazard in experimentation.

The Internal Combustion Engine

The most valuable use of wood gas is probably as a fuel for the internal combustion engine and here both types of wood gas will work well. The technique for using gas directly from a generator is considerably different from what's required to use fuel from a storage tank. This is a special case of the general information.

On the plus side wood gas burns cleanly in a regular internal combustion engine and as a fuel it has a high "octane" rating or resistance to preignition inside the cylinder. On the minus side it is lower in heat value than other fuels.

The significance of this is that wood gas can be burned in Briggs and Stratton engines, Wisconsin engines, Ford and Chevy engines and even diesel engines. The high "octane" rating may only have significance to the dedicated wood gas user so I will come back to that after covering the disadvantages of the lower caloric value of the fuel.

An internal combustion engine is basically an air pump. The physical dimensions of the inside of the engine limit the maximum amount of air that can move through it. There is no such limitation to the amount of fuel that can be added to the air. So the trick to getting more power out of an engine is to get it to pump more air. However the air and fuel must burn to produce any power and this will only happen within a narrow range of air and fuel mixture ratios (by weight). With a gasoline engine the air/fuel ratio is about 14 1/2 to 1, air to fuel. Reduce the quantity of fuel and ignition of the mixture in the cylinder will soon stop. If you increase the fuel beyond the ideal air/fuel ratio all of the air in the cylinder will burn before all of the fuel can burn. This will waste fuel. Thus an internal combustion engine is limited in output by the amount of air it can "swallow" and this also limits the amount of fuel that can be taken in.

When burning wood gas there is also an ideal ratio of air to fuel but the limiting factor is still the amount of air the engine can pump. You have a fuel that is lower in heat value than other fuels and cannot produce as much power per pound. The net result is that an engine running on wood gas produces less power at the same speed (pumping the same amount of air). It is a loss of about 20%. The engine will only produce about 80% of the power it would if run on gasoline.

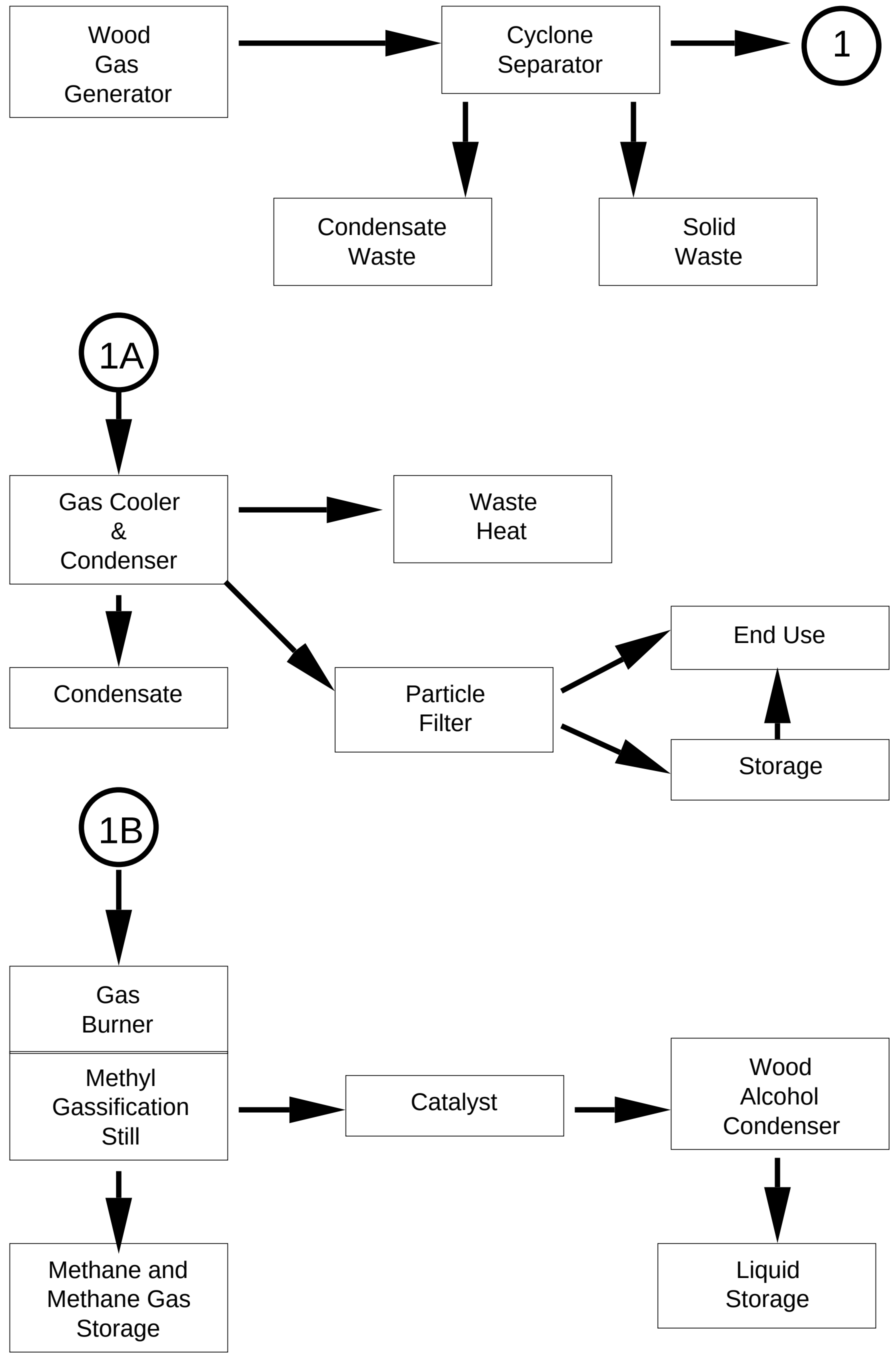
As an example, if we were burning wood gas in a 3 1/2 horse power engine we could only count on getting 2.8 horse power out of that engine. You would need an engine capable of developing 4.2 horse power on gasoline to give you the same 3 1/2 horse power output. For practical purposes its an easy matter to use a 5 horse power engine instead of a 3 1/2 horse power engine, but the necessity for this must be kept in mind.

Another "drawback" of wood gas is its lack of lead. I consider this an asset but some older engines won't. The advantage of fuel gas is that its a relatively safe low tech fuel that can be fed to any old cheap chunk of junk yard iron to develop power. But this older iron was developed with soft valves that depended on tetra-ethel lead to lubricate them. Use with fuel gas will likely cause these valves to burn and the engine will lose compression. The solution here is to try to find an engine designed for low lead gasoline or for natural or LP gas fuels. These engines will have hardened valves and seats.

Wherever possible the wood gas user is advised to use already existing controls to adapt an engine to wood gas use. Gas supplied at pressures of up to 5 psi is close to the pressures used to distribute natural gas. Where it's available natural gas has been in use for many years running industrial and irrigation engines. Controls for supply and mixture of natural gas are readily available and can be adapted with very little trouble. This presupposes that the fuel gas is held in a tank and supplied to the engine at a constant density and pressure. In the case where producer gas is consumed directly from the gas generator the pressure and density are controlled by the engine itself through engine vacuum.

Typically, in a direct installation, gas flow from the burner to the intake manifold is sustained by the running engine. Engine manifold vacuum pulls the "smoke" through the burner and draws combustion air in, it draws circulating fuel gas through the cyclone separator, through the gas cooling stages, and through the final filter into the engine. Because of this the engine must be developing vacuum (pumping air) before the gas generator can work. But the engine must have fuel before it can be run to produce a vacuum. The solution to this "chicken or egg" quandary can be solved several ways.

WOOD GAS BLOCK DIAGRAM



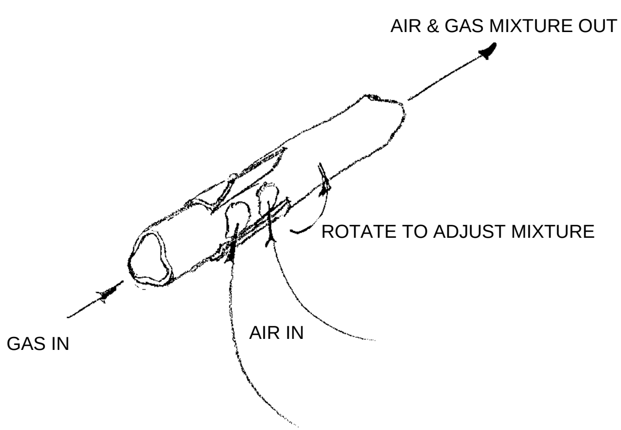
An electric powered blower can be installed in the induction tubing just after the burner outlet. This will provide vacuum to start the burner and will feed fuel gas to the engine so that it can be started and run. The disadvantages are that the blower will be subject to the high heat and unconditioned gas leaving the generator. This will destroy the blower. Moving the blower downstream to the other side of the gas cooler might seem to be the solution here but you will find that the low vacuum which a standard squirrel cage blower can generate is not going to be enough to efficiently draw fuel gas through the obstructions of the

cyclone separator and the gas cooling stages. Use of a high speed, high efficiency centrifugal blower of the type used on a blacksmith's forge will partly overcome these restrictions. This is the type of blower you will need if you want to fill a storage tank.

Of course, the user can try and get the fuel in the gas generator burning and then just crank the engine over with the starter until the draw from it pulls enough fuel gas in to start it. You will find that this takes quite a while though. It will require a large battery capacity and will result in the eventual destruction of the electrical starter through overheating.

Another method, used successfully by Mother Earth News in their work, requires starting the engine on gasoline and then switching over to fuel gas on the fly. One way that this can be done is by piping the fuel gas into the top of the carburetor on the running engine. Gasoline is shut off to the carburetor and fuel gas, mixed with air, takes over running the engine. This sounds easy but getting the transition to occur smoothly between fuels (to occur at all) is very difficult. The Mother Earth method of accomplishing this was to place a "T" in the induction system. The carburetor was mounted on one side of the "T" and fuel gas was piped to the other. A flapper valve was placed at the junction of the "T" so it could select one fuel system or the other. This method works smoothly but requires a throttle body in the fuel gas system in addition to the one in the carburation system. The single advantage to piping the wood gas into the top of an already existing carburetor is that speed regulation of the engine is done with the existing hardware of the carburetor itself, thus it could be used with an existing machine (generator, pump, tractor, etc.) without modification. All of these starting methods have specific drawbacks.

CRUDE CHAMBER FOR MIXING AIR AND GAS FOR A CONSTANT RPM ENGINE



The Pony Engine

The method I have finally adopted to get around these disadvantages is to use a small gasoline engine which can be connected and disconnected to the main engine with a clutch. The drawback here is that it is not a compact method and is more useful with a stationary engine where space and weight are unimportant. Using this method the small engine can be started and used to bring the main engine up to speed with the ignition shut off. This has the advantage of prelubing the engine with oil before a load is applied and the main engine can be motored over for as long as it takes to light the burner, draw in fuel gas, and allow the temperature and density of the fuel to stabilize. A flick of the ignition switch will then start the main engine and the "pony" engine is disengaged.

I used a gasoline engine as a "pony" engine because I was experimenting with a 350 cubic inch Chevy V8. If the engine is small enough it could be motored over using an AC or DC motor and either power line or battery current.

The pony engine method of starting works well with a stationary engine or where space or weight are not a problem. Where these are considerations the dual fuel approach is worth the effort.

A diesel engine can also be run off wood gas with almost no modification. In this case the engine will be started and run up on diesel fuel. The fuel gas supply will require the usual air mixer and a throttle body before entering the induction of the engine. If constant speed is your goal you will will also have to add an external governor to control the fuel gas throttle body. Once started and switched over to wood gas the diesel throttle is set at idle and the small amount of fuel injected is used to ignite the air/fuel gas mixture in the cylinders. Speed is controlled by the fuel gas throttle body.

I mentioned earlier that wood gas had a high resistance to "knock" or a high "octane" rating. This has some interesting ramifications for someone who is not content to put up with a reduction of power while burning wood gas. Modern gasolines will tolerate a compression ratio of around 9 to 1 before the engine starts to knock and self destruct. Wood gas and alcohol will tolerate compression ratios up to 13 to 1 before this happens. So it would be relatively easy to build an engine based on a high output modern design, using racing parts, which would recapture all of the lost horse power that wood gas costs through higher efficiencies. The efficiency figure of 28% for a gasoline I gave earlier is not immutable. A crude gasoline engine might only get 20% efficiency while some all out racing engines would get as high as 50%. The typical modern engine with overhead cam, fuel injection, and electronic ignition and control systems will get in the neighborhood of 32%. If your philosophy of power production justifies the expenditure this may be a productive path.

Methyl alcohol is the last fuel I will discuss. Racing engines have been run on alcohol for a long time. The now obsolete Indianapolis 500 engine known as the Meyers Drake "Offy" was a four cylinder engine of about 155 cubic inches which routinely produced 750 horse power on alcohol. An engine burning alcohol fuel has a very high knock resistance and so can use the highest compression ratios to improve efficiency. On the other hand methanol requires a lot of heat to evaporate it into a vapor, this makes an engine very hard to start. In addition methanol has much less heat content than gasoline so it requires much more fuel to do the same work. This means custom jetting carburetors for alcohol -- beyond the range which their manufacturers designed them for. On top of that alcohol is very corrosive and will damage metals, gaskets, fiber parts in carburetors, and hoses not specifically designed to handle it. It is also one of the cleanest burning fuels available. It is quite possible to have a roaring alcohol fire and not even be able to see the flames in the daylight. So methanol is a mixed bag. It's available in quantity but you will need a lot of fairly sophisticated mechanical knowledge to make use of it reliably; more than this article can cover.

The most direct applications for wood gas are straight-forward. For example, running a small gas powered generator to charge your battery bank. But consider some other ideas:

A removable flexible hose carrying wood gas to the intake of your farm tractor so that PTO-driven implements like saw mill, chippers, composting hammer mills, and large electric generators could be driven on wood gas without any change in the farm tractor.

A large 350 cubic inch V8 engine running at 1900 to 2000 rpm could be used to directly drive a large three phase motor. The imposed 60 hertz line frequency would make this overdriven motor act like a synchronous generator, feeding electricity back into the grid and earning income as a small power station.

Installation of a large V8 engine and truck transmission in a bulldozer chassis, along with the wood gas generator and filters. By running in low gear this engine will directly replace the slow speed diesel which normally powers such a machine. I have already built this machine and it is practical.

And of course, as Mother Earth News proved, a wood gas generator can be used to power a car or truck. In fact a lot of Europe ran on wood gas during World War II fuel shortages.

With modest mechanical skills this is a technology you can use now, and it's far safer than steam.

Access

Author: Clifford W. Mossberg, POB 75273, Fairbanks, AK 99707
Plans for wood gas burner units:
The Mother Earth News Plans, POB 70, Hendersonville, NC 28793, Wood Gas Generator, Plan #84030
Parts, hardware, and complete burner units:
Cloidal Cam Engineering Inc., POB 244, Prior Lake, MN 55377
ESMCO, 5555 Boon Ave. N., Minneapolis, MN 55428

Wind Generator Tower Height

Mick Sagrillo

Most of us are afraid of heights, or at least have a pretty healthy respect for heights. Not many folks fall into the Gonzo climbing category. For most people with generators, this poses a problem. Wind generators don't do very well on the ground. You've got to get them out of the box and way up there. But how high is high enough?

There are two reasons to get your wind system way up there; wind speed and turbulence. We'll explain these and offer some reasonable guidelines for the proper placement of your wind generator somewhere between the ant hills and the ozone layer.

The Cube Law

Let's get the math out of the way first. The power available to the blades of a wind generator can be expressed by the equation:

$$P = \frac{1}{2} \, d \, A \, S^3$$

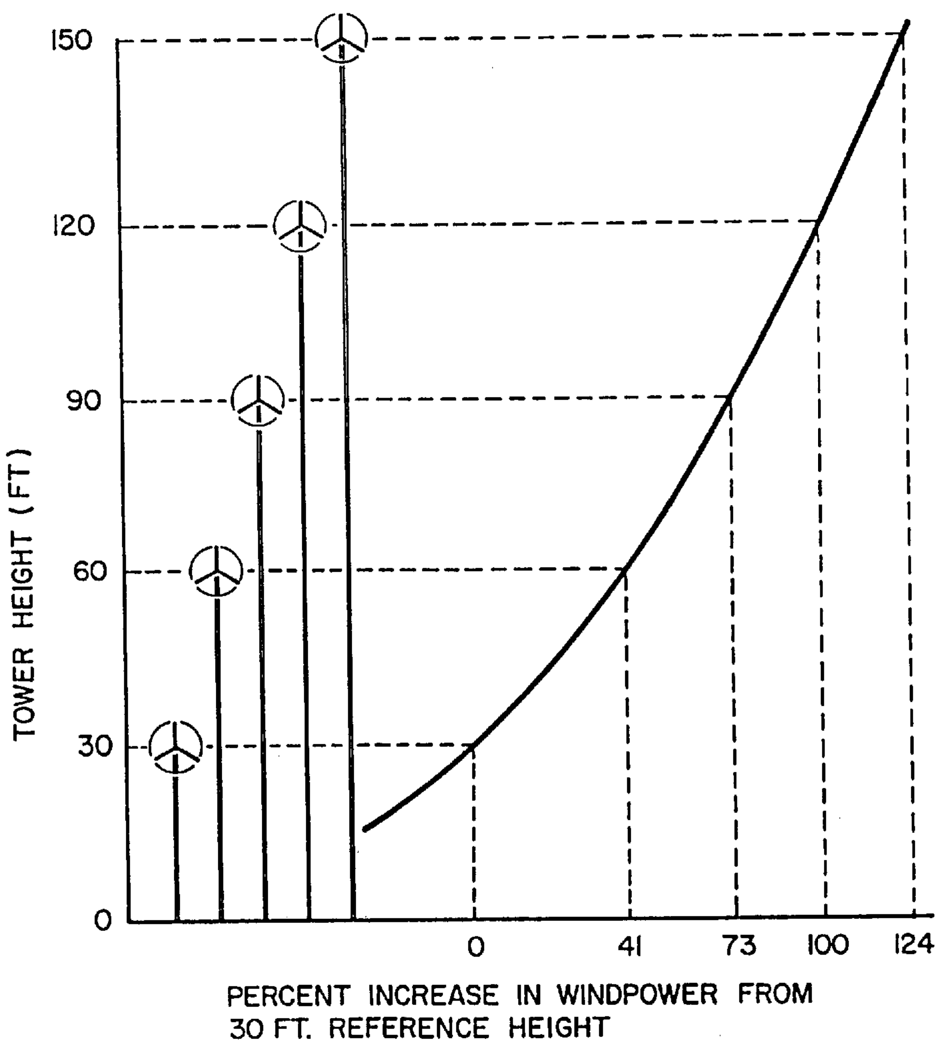
where P is power at the rotor (system efficiency is of no concern here); d is the density of the air mass (this will change from winter to summer); A is the swept area of the rotor (the solid disc that the rotating blades present to the wind); and S is the velocity of speed of the wind. What we're concerned with here is the wind speed, S. The most important part in this equation for us is the "3" after the "S". The three stands for "cubed", or S X S X S. What this means is that very small increases in wind speed result in substantial increases in power available to the rotor. Doubling wind speed yields an eight-fold increase in power!

For example, say our wind generator produces 100 watts at 8 mph. If we were to double this to 16 mph, our wind generator would be capable of putting out 800 watts. That's an 800% increase in available power! Even small increases in wind speed result in big gains. Jumping from 8 mph to just 9 mph gives us a 42% increase in available power.

Applications

So what's this got to do with towers? Well, the higher you go off the ground, the stronger the wind becomes. Because there is less surface friction and fewer objects for the wind to bump into and move around, the air can flow freer and faster.

The figure to the right (compliments of Bergey Windpower Company) depicts the relationship of tower height to increase in wind speed. We can extrapolate from the diagram that going from a 30 foot tower (on level ground with no obstacles) to a 70 foot tower will increase the available wind by about 50%. Using our previous example, that would be like going from 8 mph to 12 mph. Using the cube law, this would give us a 338% increase in power available to the rotor.



The Lesson

The bottom line to all this is that we can get radical increases in available power to our wind generator by just going higher. Using the above example and in terms of dollars and cents, we could have gotten a 300% increase in power by just installing two more wind generators and towers. It should be obvious to all but the most tower-fearful that going up is cheaper and less trouble than adding more wind generators. (Another way of increasing power is to put up a bigger wind generator. However, taller towers are usually cheaper than bigger wind generators.)

But how high is high enough? Using the above rationale, maybe we should go all the way to the stratosphere. Not so. Towers aren't free. There comes a point where the additional tower structure is not worth the gains in power. How do you determine

this? Let's start back down in the other direction and find out what our minimum tower height might be.

Turbulence

As the wind passes over the ground, it bumps into trees and houses and passes over hills and valleys. All of this causes friction between the wind and objects on the earth, resulting in the slowing down of the air mass. Because air is a fluid and reacts similarly to water, we can look at a stream to see this phenomenon in action. Water along the bank swirls and eddies around, while the water in the center of the stream keeps moving right along. This swirling action of the wind is called turbulence. What we want to do is minimize this turbulence and allow for the free flow of air past our wind generator rotor.

The best way to eliminate turbulence is to get up above it. And the higher the better. Are we headed back up to the stratosphere? Not necessarily. The basic rule of thumb to follow is to get the rotor at least 30 feet above anything within 300 feet. For example, say we live on an open plain. The only visual obstacles for miles around are our house, shop, and barn. This one's easy. If the barn is the highest building at 22 feet, we'd want to get the bottom of the rotor 30 feet above that. If we have a 10 foot rotor diameter, we'd add 5 feet to the height, for a minimum tower height of 57 feet (22 feet + 30 feet + 5 feet).

If, on the other hand, we live in a cabin in a five acre clearing in the woods, we have a different problem. Let's assume the cabin is 15 feet high and the trees are at 60 feet. Using the rule of thumb and the generator with a 10 foot rotor, we estimate that we will need a tower about 50 feet high (15 feet + 30 feet + 5 feet) and in the center of the clearing to make the 300 foot limit. But in this case, we'd still be below the tree line. We might as well have left the wind generator in the crate. As far as the wind is concerned, the rotor is in a hole! That's because the ground reference for the wind is not our ground reference, but the tree line. In this instance, we'd need a 95 foot tower (60 feet + 30 feet + 5 feet). And that would be the absolute minimum. That's because trees continue to grow while towers don't. I know of one family who installed a wind generator only 10 feet above the pines to save money. Eight years later their rotor is 5 feet below the tree line and the generator doesn't produce a watt.

Wear and Tear

Another reason to eliminate turbulence is because it causes considerable stress on the wind generator. Constant swirling winds cause the rotor to accelerate and decelerate continuously and to hunt around for the wind. These stresses compound wind generator wear and lead to more maintenance, at the very least. In severe cases, excessive turbulence can cause a catastrophic breakdown of the system.

For example, I have two wind generators mounted in an east/west line about 300 feet apart. When the wind is coming directly out of the west, the generator to the east hunts around so much that it hardly produces anything. If we could see the wind, it would look very much like the wake of a boat with the western generator causing the wake. The stronger the wind blows, the worse the hunting gets. In the rare case that we get a wind straight out of the west, I shut the eastern machine down. No sense in beating up the wind generator!

How High?

So back to the original question: how high is high enough? You've got the tools to answer that question here. You know the absolute minimum height and you know the increases in available power to the wind generator as you go above that minimum. To answer the question of how high is high enough, you have to take a look at your power needs, the dollars you can spend on a tower, and your fear of heights.

Access

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Ice Farming

Stan Krute

Though my home is in the country, I generally cultivate ideas, not plants or animals. Every winter, however, I do turn farmer, and bring in bushels of one of nature's hardiest crops: ice.

Some Pluses, No Minuses

Ice farming is one of the finest forms of agriculture. It's easy, fast, foolproof, inexpensive, and pest-free.

Ice-farming lets me turn off my propane refrigerator around Thanksgiving, and not turn it on until spring. I put a few coolers on the north side of my house, then fill 'em with ice and food. In addition to saving energy, I can fend off some of those grotesque winter weight gains: it's tougher to go outside to a cooler for a snack than open an indoor refrigerator, and that's a useful deterrent.

Finally, ice-farming's based upon magical scientific facts that I can consider and marvel at in spare mental moments. Here are a few of them:

Hot and Cold, Candy and TV

Matter consists of atoms and molecules in motion. Each of these moving particles possesses energy related to its motion. This energy is known as **kinetic** (from the Greek word for moving) **energy**. The greater a particle's motion, the greater its kinetic energy.

The **temperature** of an object is a measure of the average kinetic energy of its atoms and molecules. High temperatures correspond to high kinetic energies; low temperatures correspond to low kinetic energies. Hot objects have atoms and molecules that are moving relatively quickly. Cold objects have atoms and molecules that are moving relatively slowly.

Heat is a form of energy which, when applied to matter, increases the motion of its constituent particles. The temperature goes up. Heating an object means increasing the kinetic energy of its atoms and molecules.

Cooling an object means reducing the kinetic energy of its atoms and molecules.

Applying heat to an object is like feeding sugar-laced **candy** to **children**. Their kinetic energy increases. Cooling an object is like sitting them in front of a **television** set. Their kinetic energy decreases.

The Charitable and Democratic Nature of Heat

If you put a group of objects of different temperatures into a thermally-insulated enclosure, then wait a while, the objects will end up at the same temperature. That's because heat is quite charitable and democratic. Hotter objects share their energy with cooler objects. In fact, the bigger the difference in temperature between objects, the faster the transfer of heat energy from the hot ones to the cool ones. Once all the objects are at the same temperature, they stay equal. They've reached thermal equilibrium.

Heating, Melting, Cooling, Freezing

When you add heat to a substance, its temperature rises. For a given amount of substance and a given amount of heat energy, the change in temperature depends on the substance and its state. For example, it takes 33 times the energy to raise the temperature of a pound of water 1 degree as it does a pound of lead. This property of matter, the amount of energy required to change the temperature of a set amount of it by 1 degree, is called its **specific heat capacity**. Interestingly, water has the highest specific heat capacity of common substances. Ice has half the specific heat capacity of water. It takes a lot of energy to warm either of them up.

At a certain temperature, applying more heat to a solid substance will no longer raise its temperature. Instead, the object will melt. Once it totally melts, the temperature of the now-liquid substance will once again rise. The amount of energy that must be added to a substance at its melting point to make it a liquid is called its **heat of fusion**. The same amount of energy must be removed from a liquid substance to make it solid.

Yum Yum ! The Utility Of Cold

As stated above, low temperatures mean that molecules have less kinetic energy. They're moving slower. The interactions between molecules are less frequent, which slows down chemical reactions. That's why cold is useful: it slows chemical reactions. Life, which is energized by chemical reactions, slows down at low temperatures. The bacteria that turn good food into poisonous gunk are a form of life. That's why food lasts longer when its kept cold.

How Ice Helps Keep My Food Cold

I put ice and food in my cooler. The cooler slows down the movement of heat energy. I keep the cooler on the north side of the house. That way, only a minimal amount of heat energy from the sun hits the cooler during the day.

Of course, the sun warms the outside air, and the air surrounds the cooler. When the outside air is warmer than the inside of the cooler, heat moves into the cooler. In winter, that heat movement is slow and minimal, since the outside air is usually not very warm.

Heat that does enter the cooler raises the temperature of the substances within. It has to heat the ice, as well as the food, which slows the temperature increase. If the temperature hits 32°, and there's still excess heat energy, it has to melt the ice before the temperature will rise more. And if the ice all melts, there's still a bunch of very cold water in the cooler, and we've seen above that it water absorbs more heat energy than any other common substance before it'll go up in temperature.

You can think of ice as a well-lubricated thermal flywheel.

Two Simple Techniques: Gleaning and Cultivating

When it's **really** cold, I glean ice. I go out to the nearby creek with a breaker bar, bang away at the ice, and carry the pieces in a bucket to my cooler.

When it's not so cold, I cultivate ice. I set a children's plastic wading pool out at night, and fill it with an inch of water. In the morning there's ice. I go out and break it up with a rock, and carry the pieces in a bucket to my cooler.

In Summary

Ice farming is the simplest sort of agriculture. Every winter it keeps my food cold at very low cost. The tools and techniques are simple. I only have to do it once a week or so to keep my food supply healthy.

Access

Stan Krute is a pinhead. He may be reached at 18617 Camp Creek Road, Hornbrook, California 96044 • 916-475-3428.

For more facts about heat and cold, Stan recommends **Theory and Problems of Applied Physics**, by Arthur Beiser, a Schaum's Outline Series book, published by McGraw-Hill.

An Introduction to THE BASICS

Richard Perez

The next some ten pages contain an introduction to efficient use of electric appliances and renewable energy site surveying. We need to make intelligent, cost-effective, decisions about our systems. If you use this information, then your system will provide top service at the bottom dollar. If you rent your power from the grid, then this information will cut your power bill. It will also reduce your share of the pollution made by the utility. So let's take a quick tour of the hard-won information ahead.

IN THIS ISSUE

The Basics– Power Use

Specific tasks require electric power. The better we know our appliances, the better we can estimate the amount and type of electric power we need. The emphasis here is on planning ahead and this saves thousands of dollars in overall system costs. Deciding which appliances are appropriate for electric power, and which are not. Selecting the most efficient appliance to perform a particular task is critical. Efficient appliances cost more to buy, but they are much cheaper to OPERATE. Before all else, estimate the power needs of the system. Without this information, it is impossible to design the system.

The Basics– Site Survey

The idea here is graciously noting what Mama Nature offers. Examine the site minutely for possible power sources. This information determines if a site has photovoltaic, wind, and/or hydro power potential. You can determine, with high accuracy, the amount of power potential on the site. Match the information generated by the Site Survey with the Power Use information. Both determine the next step, System Design.

COMING UP IN HOME POWER #22 & #23

The Basics– System Design

Match up what Mama Nature offers with what you need. If you did a thorough survey of your appliances in Power Use and if you've done your Site Survey, then the next step is System Design. System Design harnesses your available renewable power sources with the power you need. System Design specifies hardware list. This specific hardware produces, processes, and stores the electric power you need. The system will use three kinds of hardware: Power Sources, Power Processors, and Power Storers.

The Basics– Power Sources

The most effective renewable power sources are sunshine, falling water, and wind. The Site Survey has already determined the renewable sources you have. What remains is a consideration of how to convert the power source(s), into electricity. The information in Power Sources is a discussion of photovoltaics, hydro, wind, and engines. First, make the decision to use a particular power source. Next, specify the hardware to fit your site and power requirements.

The Basics– Power Processors

Power Processing equipment comes in may forms. Inverters are processors that convert low voltage DC into 120 vac. Controls regulate system production and performance. Instrumentation meters performance and provides information. All systems, except the smallest, will use an inverter, electronic controls, and instruments.

The Basics– Power Storers

In today's technology, Power Storage means batteries. Virtually every system will use electrochemical power storage. This information deals with choosing the proper battery for the job, sizing it, and operating it.

A Note on this information…

Although I am writing this, the information comes from many sources too diverse to list. It comes from lifetimes of actually living on these systems. The information in these basic articles is not speculation but is direct experience. While I get to write it, many others have lived the experience and taken the data. Karen and I live and work with photovoltaic systems. Most of the PV related info is from us. I got this information from the systems I installed and maintained for customers. The hydroelectric information comes from Bob-O Schultze (Lil Otto Hydroelectric Works!), Don Harris (Harris Hydroelectric Systems), and Paul Cunningham (Energy Systems and Design). They are hydro turbine makers and users. The wind electric information comes from Larry Elliott and Mick Sagrillo (Lake Michigan Wind & Sun). Information about system design, power processing and power storage comes directly from what I have learned through our systems and those of our previous customers and from neighbors and from Home Power readers, and the list goes on…, and on…

The Basics- Power Use

Richard Perez

EVERY WATT NOT USED IS A WATT THAT DOESN'T HAVE TO BE PRODUCED, PROCESSED, OR STORED.

Careful attention to the consumers of electric power, our appliances, really pays off in renewable energy systems. A rough rule of thumb for RE systems is that a dollar spent on an efficient appliance will save three dollars in system components. Not a bad deal. Efficient electric power use also pays off in lower utility bills for grid connected folks and less pollution produced by the utilities. This section of The Basics provides the information required to evaluate your appliances and to how to use electricity more efficiently.

To do or to do without?

I am not writing this article to discourage you from using electricity, but to show you how to get the maximum use out of the power you do use. This is especially important in renewable energy systems. Every watt-hour of electrical power must be produced, processed, stored, and consumed on site. Doing this via independent, self-contained and non-polluting methods is not cheap. Most of us making our own electricity are doing so at the cost of between $0.40 and $1.15 per kilowatt-hour of power. This is about ten times the average cost charged for power by commercial electric utilities. This information assumes that you wish to save power and thereby money. You will save either in your equipment cost if you are making your own power or your power bill if you are renting your power from a commercial utility. This seems obvious enough, but really conservation is a temporal mirage. Read on…

The real problem is not our appetite for electric power, but how we produce the power.

Power produced from coal, nuclear, and oil sources comes with deadly environmental warts attached. If, in our wildest dreams, everyone's electricity was produced by non-polluting renewable methods, then what is the point of conserving power? The only way to waste the power, produced by PV, hydro, or wind, is NOT to use it. The environmental price tag attached is zero. Nature offers this power to us and we'd be fools to refuse it.

The Importance of Efficiency

We have better things to do with our hard–earned bucks than spending them on power hardware or utility bills. What follows logically is that every watt-hour of power we can avoid using is a watt-hour of power we don't have to pay for. To this end, cast a jaundiced eye on every appliance using electricity in your home.

Each Appliance's data

Ask only two questions of each appliance: 1) how much electric power does the appliance consume? 2) How much time does the appliance operate? Ask these two questions of every appliance, don't skip any.

The nameplate contains the appliance's power consumption (usually expressed in Watts or KVA). This figure represents a worse–case scenario. The average power consumption of most appliances is less than that printed on their exterior. If you have the technology to measure the appliance's power consumption, then certainly do so. Use measured data instead of the nameplate data.

The time an appliance spends operating is an estimate expressed as number of hours per day. Some appliances, like power tools and lights have humans operating them. It is easy to estimate their operating time. Other appliances turn themselves off or on without human attention, like refrigerators and freezers. These automatic appliances can be more difficult to estimate without actually measuring their operating time.

The appliance's power consumption is determined by multiplying its average power consumption by the average number of hours per day it operates. That's it. For example, if a light consumes 15 watts and is operating 5 hours daily, then the light will consume an average of 75 watt-hours daily (15 watts X 5 hours = 75 watt-hours).

Entirely Appropriate Appliances

Electricity accomplishes some chores better than any other power source. The question is not whether to use electricity, but what particular type of electric appliance to use.

Don't worry about having to keep track of all this specific data. All the data for appropriate appliances, detailing their power consumption and their average on–time, is on a table at this article's end.

A note on phantom loads: Phantom loads are appliances that appear to be off when you are not using them, but in fact, they are still alive and consuming power. These appliances represent a gross misuse of electricity and waste large amounts of power. Here are some fast ways to recognize phantom loads. Any device with an electronic clock or timer is a phantom load. Any device that operates by a remote control is a phantom load. There are other types less easy to recognize, but they are mentioned below under the specific type of appliance.

Refrigeration

Refrigerators and freezer are the highest power consumers in an electrically efficient system. For this reason, only consider the most efficient refrigeration equipment.

As an example of efficient refrigeration, I cite the Sun Frost RF-12, a 12 cubic-foot refrigerator/freezer. The RF-12 consumes about 300 Watt-hours daily (about the amount of power produced by one and one–quarter PV modules). The RF-12 costs about $1,550.

An example of inefficient refrigeration, I cite virtually any frost-free unit that spits ice cubes out its door. Costing about $600, a 12

cubic foot model will consume about 1,500 Watt-hours daily (about the amount of power produced by seven PV modules).

The bottom line here is that the initially more expensive, but vastly more efficient, Sun Frost will cost about $2,800 to buy and operate for ten years in a renewable energy system. This includes not only buying the refrigerator/freezer, but also the PV panels (or whatever power source), regulators and batteries to source the refrigerator. The conventional refrigerator, while initially cheaper, is more expensive to both buy & operate; it costs $6,100 over 10 years.

The big difference here is efficiency. The efficient refrigerator will have three to five times more insulation and better door seals. It uses a more efficient compressor and evaporator located where the waste heat will not transfer back to the box. There are no thermally conducting metal fittings used through the box's insulation. All these features cost money in the originally manufactured product, but the money spent here comes back many times over in power savings.

Refrigeration equipment operates directly on low voltage DC or via an inverter. Models are made with inputs that accept 12 VDC, 24 VDC, or 120 vac.

Lighting

Lighting is so important not because these devices consume large amounts of power, but because lights spend so much time operating.

The most efficient type of lighting that is suitable for home use is fluorescent. Gone are the days when fluorescents buzzed, flickered, and made everyone looks like pale wraiths. Today's fluorescent tubes can produce flicker-free and color-correct light more efficiently than ever before.

The best types of fluorescents are electronically ballasted types like the Osram EL series. Use this type of lamp for any light that average one hour or more per day operating. Period. For example the Osram EL-15 compact fluorescent produces as much light as a 60 watt incandescent lamp while consuming 15 watts of power. That's four times more efficient! Using a single EL-15 compact fluorescent light will save the RE powered user about $360 over the light's 10,000 hour lifetime. The same lamp will save the grid connected user about $34 on his electric bill. This does not include tons of carbon dioxide, gallons of acid rain, and a pound or two of assorted radioactive waste.

A home may have twenty or thirty lights wired into its electrical system. This doesn't mean that they ALL have to be operating ALL the time. A good rule for RE powered household is, "One Person, One Light." This means that every individual within the household can burn one light wherever they may wish. If a person leaves the room, then he shuts off that particular light and turns one on elsewhere. As a person moves through the house, his light follows him. Sounds simple enough, but try teaching this to your city friends who come to visit.

Another factor effecting lighting power consumption is the placement of the lights. Using area lighting and indirect lighting wastes power. It squanders much of the light where it is of little or no use. The most efficient place to put a light is right where you need it. The radiation of light follows the inverse square law. This means that a light that moves twice as far away from an area sheds about one-quarter the amount of light on that area. At three times the distance, the incident light on the area is one-ninth as strong. And so on. If you are working at a desk for instance, a 25 watt desk lamp will provide more useful light than a 200 watt lamp screwed to the ceiling.

If you are designing your system from scratch, then design in fluorescent lighting and you will save a bundle on power hardware. If you already have a system, install fluorescents and use the power for better things elsewhere. If you are grid connected, use fluorescents and give our planet, and your power bill, a break.

The most cost effective fluorescent lights run on 120 vac. Types like the Osram ELs function quite happily on inverter produced modified-sine wave 120 vac. While very small systems will still find 12 VDC lighting attractive, a system installing five or more lights will find 120 vac compact fluorescents more cost effective. Purchase cost of the 120 vac fluorescent lights is about half their 12 VDC counterparts. If you're installing five lights, the savings on the lights will pay for a small inverter.

Power Tools

Power tools are not usually major consumers unless you operate a wood shop or other business employing power tools. Usually power tools operate for a few seconds. Even though they consume a large amount of power, they don't do it for very long. The major concern here is making sure that the system has enough power on hand to meet the surge requirements to start and operate the tool when heavily loaded. In most cases, these tools operate on 120 vac and the inverter becomes the limiting factor on tool performance. If you are into big electric motors, then make sure that your inverter is robust enough to handle the action.

Several types of power tools bear mentioning. Any power tool that employs "solid-state" power or speed control is suspect. Many of these tools (but not all) use either silicon controlled rectifiers (SCRs) or triacs (two SCRs back to back) for power control. This solid-state power control device assumes sinusoidal power input. SCRs will not function on inverters. In most cases, the SCR becomes a crispy critter within seconds of being powered–up by modified-sine wave inverters.

Washing Machines

Washing machines are merely large motors. They follow the same rules as power tools. If the system produces enough power and the inverter is capable of handling this power, then clothes washers perform quite well in RE systems. The same is true for gas-fired clothes' dryers.

An average washer will consume about 800 to 1,200 Watts and require about three times that amount on starting and spin surges. Consider washers with electromechanical timers. Some models with electronic timers become bemused when confronted with the modified-sine wave inverter power. Electronic timer models are also phantom loads and consume power even when they appear inoperative. A survey of HP readers shows Whirlpool (also marketed by Sears as Kenmore) washers work well on just about any inverter.

Electromechanical Kitchen Appliances

Kitchen appliances using motors operate easily on RE systems and represent the same case as power tools. While that swell Champion Juicer may consume 700 Watts or so, it only operates a few minutes daily and doesn't represent a large load for the system. The same is true for almost all kitchen appliances. In our experience mixers, juicers, beaters, food processors, and coffee grinders are all convenient and compatible with RE systems.

Electronic Entertainment

The list of electronic entertainment devices includes: TV receivers, video displays, VCRs, satellite TV, stereos, tape recorders, and radio receivers. These devices produce information as their output, and since information doesn't weigh anything,

entertainment electronics generally consume very little power. As information junkies, we often have these devices operating for many hours at a time, and their overall power consumption can become significant. Let's look at potential big consumers.

The power consumption of a TV set or video display is directly proportional to the size (area) of the screen. This information applies to displays which use a cathode–ray tube (CRT) as a display, as virtually all TVs do. A five inch diagonal CRT has an area of 25 square inches and consumes about one-third the amount of power of a 9 inch diagonal CRT with an 81 square inch screen. The bigger the tube, the more electric power it consumes. Color CRTs use three electron guns, one to bombard the red phosphors on the tube's screen, one to get the blue phosphors, and one for green. Color CRT displays consume about three times the amount of power as a same sized black & white display. If you consider that the average American TV set spends over five (5) hours daily operating, then even small changes in the TV's power consumption will impact the overall power bill. This information applies to TV displays operated either on 120 vac via the inverter, or in displays powered by 12 VDC directly from the battery. Most modern 120 vac TVs employ remote controls and many have the "instant start" feature. Both of these features are notorious phantom loads. Any TV gear with these features must have a switched outlet or switched plug-strip in order to really turn the gear off.

VCRs consume about 25 to 70 watts of power and run well on just about any inverter. All VCRs are phantom loads because they contain an electronic timer. Use them on a switched outlet or plug strip. The same is true of satellite TV equipment which consumes about 30 watts operating and surges to several hundred watts when operating the dish positioner. Most satellite TV systems want to keep the Low-Noise-Amplifier (LNA) on the dish powered up all the time for thermal reasons. If the LNA is constantly powered–up, then is more stable and requires no warm–up period (about 10 minutes to 2 hours depending on outside temperature). In most systems, keeping the LNA hot will consume about 15 to 20 Watts, and that's 24 hours a day (360 watt-hours daily). If you can wait a few minutes for your satellite TV system to warm–up, then consider it a phantom load & totally disconnect it when not in use.

Stereo and audio equipment don't consume much power at low volumes. The major problem with 120 vac powered sound gear is inverter noise. About half the audio equipment designed for 120 vac operation will have a 60 cycle buzz on the speakers. This is because the power supply within the stereo gear lacks adequate filtration to stop the inherent noise made by modified sine–wave inverters. About half the stereo gear is well–designed enough to run quietly, with no interference problems. So run prospective audio equipment purchases on an inverter before buying them. The happiest RE powered audiophiles I know all have 12 VDC powered audio gear. Fact is that you can get high quality, high powered, audio components for automobiles. These units perform very well in RE homes. The only trick is to use regular home sized speakers, instead of automobile type speakers. In particular, the Pioneer automotive CD units are getting rave reviews from HP readers.

Radio receivers are minuscule consumers of power, from a few watts to 30 watts. All radios are susceptible to interference and noise. This noise can come from the inverter (especially if the inverter powers the radio). It can come from controls (like PWM charge controllers), and it can come from electromechanical power sources (like wind machines and hydros). Higher quality radios ignore noise in every way possible and are worth the extra cost. DC power directly from the battery is the most noise–free way to powering this equipment, and the most efficient because virtually all radios use low voltage DC in their interior.

Water Pumping

Renewable power sources easily move water from place to place. It is simply a matter of the quantity of water to move and the vertical distance that it moves. In almost all cases, the water supply is so important as to deserve its own discrete system. This means not using the water-pumping power source for any other purpose. This assures that water will always be available, regardless of the main system's state of charge. Typically, both PV/electric systems and wind/mechanical systems are favorites for pumping water.

The most efficient electric pumps to use are low voltage DC models, rather than 120 vac models. The low voltage DC pumps will pump slowly over the entire day. A submersible DC pump moves about 300 to 600 gallons daily, at a vertical lift 100 to 200 vertical feet. DC pumps consume about 200 to 500 watt-hours of power daily.

Specialized jack type pumps, directly PV powered, can pump wells as deep as 900 feet. Other DC pumps function as water pressurization pumps and eliminate the need of a water tower at many flat sites.

The point here is that water pumping is a highly specialized system in its own right. A water pumping system is more effective if all hardware does nothing else. Water pumping set–ups are radically different in design. For example, they hardly ever use batteries, but instead pump whenever the power is available from the renewable source. More information on water pumping will follow in future Basics articles.

Communications

Communication is one of the very first electric appliances used by most systems. If you are located miles from the nearest power line, then you are probably also miles from the nearest telephone. I know of many folks who invited electricity into their homes because they needed communications with family, friends, and neighbors. The most popular mode is Citizen's Band two–way radio. These units are cheap, now require no license, and work well in localized neighborhoods. The CB radio consumes very little power, around two watts on receive and about 15 Watts on transmit. They are effective communications from five to twenty miles. Our whole crew communicated via CB radio before virtually everyone became Ham Radio Ops. Each evening everyone would check into the CB net. We'd talk about everything from pickled onion recipes, to whose pipes froze, and whose critters were ailing. The neighborhood CB net works especially well if one or more members have a telephone. This kind soul can then handle emergency telephone communication for folks on the CB net. I know of many times this has saved lives (both human and critter), saved time, saved money, and saved familial wear&tear. At about a hundred bucks installed, you can't beat the CB radio for function at a low price. These neighborhood nets work only if everyone is listening all the time, and this means– Leave the Radio ON! So wire your CB directly to the 12 VDC battery.

The situation with Ham radios is much the same as CBs, but the coverage and utility of the radio network are vastly greater. Repeaters extend the range of noise–free VHF radios to hundreds of miles, while using few watts of power. Hams routinely talk around the world on schedule, and use less than 100 watts to do

this. Those who have studied–up and gotten their Ham radio license already know how well Ham radio works. Those who can't make CB work for communication, should consider Ham radio. Sure you have to learn something about electricity, radio and electronics, but if you like Home Power, then you'll love Ham radio. Many Ham VHF repeater set–ups have what is known as an "autopatch" that will connect your Ham radio with the telephone lines. While these autopatches are not for either business or long distance phone calls, they will get you into the hospital, police, fire, and other local emergency services.

The final step in remote communication is radiotelephone (RT). Here a specialized two–way radio connects you directly into the telephone network. Radiotelephone service comes in two varieties, those you rent (IMTS, Cellular, and RCC), and those you buy. In the rental systems you still have to buy or lease your end of the radio gear and pay a charge for each minute that you use the system. This rate varies from $0.50 to $1.20 a minute, and is charged for both incoming and outgoing calls. While the radios are relatively cheap, from $500 to $1,500, the service is very expensive. For example, our RT system for Home Power spends about four hours daily active. That is 240 minutes daily, and at a buck a minute for a rental service that's $240 daily. We actually used to have a buck a minute IMTS system operating here and I used to dread hearing the phone ring. I was working just to pay the phone bill. Most commercial services are full duplex now (you can talk and listen at the same time). However, in rural areas some are still simplex (you can either talk or listen, but not both at the same time). If you need business use from a radiotelephone service, then don't use simplex. When someone is talking to you on the phone, he has a lifetime of phone habits telling him that he can interrupt you. If the service is simplex, you will not hear him interrupt you because you are talking. I have heard this interpreted by the caller as extreme rudeness. If the phone handles business communications, only consider services that are duplex.

Wholly-owned radiotelephone systems are really the best way to go. In this mode the user buys and maintains all the radio equipment and is billed by the phone company just like everyone else, with no special by-the-minute charges. You need a willing friend and neighbor, within five to twenty-five miles, with a regular phone. Install one end of the RT system at the neighbors home and plug it into the regular phone lines. Simply have the phone company run another line into your neighbor's house for your number. The other end of the RT lives at home with you. These units consume very little power, usually less than 200 Watt-hours daily, and cost between $4,000 and $8,000 to buy, license, and install. These RT systems are excellent candidates for a system all for their own, just like water pumps. Communication is essential. Isolate communication from the rest of the home's system. Here at Home Power, our Carlson Communications RT system has its own PV array of two modules, its own homebrew regulator, and its own battery of ten nicad cells. All this power hardware does just ONE thing– run the telephone.

The real expense of radiotelephones is not its purchase price or to its electric power consumption, but to how you enter the telephone network. All RT systems are small consumers of power, but some a Gawd-Awful expensive to use because of the service's by the minute charges.

Computers and their friends, the Peripherals

Computer equipment has found its way into many RE systems. For example, PVs, inverter and battery powers the Mac IIcx I am writing this on. In general, computer equipment is low in power consumption. A CPU will consume from a few watts to 60 watts. Hard disk drives consume between 10 and 40 watts. Most computers now used switching type power supplies and love the modified sine wave power out of virtually any inverter (note: there are exceptions, so read on). Many folks are operating all types of computer peripherals with no problems. The list includes scanners, modems, plotters, MIDIs, and things too fierce to mention… Displays and printers are the major power consumers.

All the information presented under TV sets also applies to computers. Most computers use a CRT for display and the power consumption of that CRT is directly proportional to its area. Big screens consume more power. Color CRTs use more power than monochrome models. Please note that I'm sitting in front of an Apple TwoPage monochrome monitor This monitor has a diagonal CRT measurement of 21 inches is as REALLY BIG. I hesitated to buy the big CRT because it consumes about 80 watts. It has made page layout for Home Power so much better and faster, that I couldn't do without it. Don't short yourself on the display. Just be sure you really need it and plan ahead for its large power appetite.

Impact printers consume around 150 watts when operating, and run on even a small inverter. Inkjet printers, like the Hewlett–Packard DeskWriters we use, are marvels of efficiency and function. The 300 dpi DeskWriter consumes about 25 watts while printing and only four watts on standby. The only type of printer that is not suitable for RE systems is the laser printer. Laser printers use SCR-based devices for power control. They will fry and die immediately if you plug them into an inverter.

We use an inverter and run all the computer gear on 120 vac. Others, like John Osborne, have placed most computer gear directly on 12 VDC where it consumes even less power. The choice is yours and wide open as computer gear can function in either environment quite well. We chose inverter operation because our computer systems are expensive and use many diverse peripherals. Using 120 vac via the inverter insured device isolation and reliable function no matter what type of binary madness is occurring.

Appropriate if used Wisely…

Some appliances are in the gray area between electric and thermal applications. In general, thermal applications are not cost-effective on RE produced electricity. Here are a few exceptions that work if they are kept down to a dull roar by the user.

Cooking

Amazingly enough a microwave oven is a very useful item in a RE electric system. The microwave is very efficient, easily run by the inverter, and can save having to start the propane or wood cookstove. While a microwave may consume over 1,000 watts, it only spends a few minutes operating. This means low overall power consumption. Almost all microwaves use electronic timers and they are phantom loads requiring the switched outlet, switched power–strip, or unplug routine.

Our resident pixel–maniac, Stan Krute, loves both waffles and popcorn. On sunny days, when his batteries are full, Stan uses his 1,300 watt waffle iron or his 1,200 watt hot air corn popper. The point is that his regulator is refusing power from the 12 panel PV array because his large (1,400 Amp-hrs at 12 VDC) battery is already full. So, Stan treats himself to a waffle or two, or maybe a bowl of popcorn. Appliances that may also be included in this list are toasters, toaster ovens and crock pots. The power consumption here is significant, but it occurs at a time when the power would be refused if it was not used. Appropriate use

squeezes every watt-hour possible out of a system. The hardware is ours already, and there are no environmental consequences.

Perhaps the best use of solar energy for cooking is the solar cooker. These things work. For example, on 31 December 1990, Karen put a large pot of rice into our solar cooker. The outside air temperature was 27.1°F. at 10:17 AM. The low temperature the night before was 3.7°F. Karen inserted the rice early in the morning, figuring that it would take all day to cook. It was done at 12:54 P.M.; and the internal oven temperature was 220°F. As a year round average, I estimate that about half our meals here are now solar cooked. During the Summer almost all of our meals are solar cooked because who needs the stove running in an already hot house?

Appliances not generally suited to RE electric power systems

Some household needs, mostly associated with heat, are not now suitable for RE produced electricity. These include water and space heating. Both these jobs require prodigious amounts of power. Heating is best accomplished by direct solar thermal, or failing that combustion, in stand-alone systems.

Water Heating

Water heating can be accomplished effectively and cheaply using the Sun's direct thermal energy. Solar hot water pays for itself very rapidly, usually less than 3 years, in both RE and grid connected systems. In non-air conditioned and grid connected homes, the electric hot water heater is the NUMBER ONE consumer of electricity. In RE powered homes, the hot water heater is the NUMBER ONE consumer of propane. So consider solar hot water for your system.

If you are going to use combustion for water heating, then consider a demand-type water heater as your first choice. Demand-type hot water heaters heat the water at the moment you need it, rather than keeping many gallons of water continually hot.

Regardless of what your tank-type water heater uses as fuel, do the DANCE OF TOTAL AND UTTER INSULATION. Use a blanket of insulation surrounding the heater, insulate all hot water pipes, and fix every dripping hot water faucet.

Space Heating

Design space heating into the house as direct solar thermal gain. This means a solar heated house with R-40 to R-60 insulation, thermal mass for storage, superinsulated windows and doors, and an air-to-air heat exchanger. If you are starting anew, then build a solar heated home. If you are working with an existing structure, then you should add insulation and other heat saving items like weather stripping, intelligent thermostats, and radiant barriers on windows.

Adding it all up

Once you have surveyed each appliance in your home, it is time to add everything up. Determine the daily watt-hour consumption of each appliance. Add all the appliance's daily consumption together to get a total amount of electric power you will need daily. This is a very important figure that will determine the ultimate price

Using Inefficient Appliances and Ignoring Phantom Loads

Total Watt-hours per day consumed	11660.6	%
Total Watt-hours per day for Phantom Loads	2472.0	21.2%
Total Watt-hours per day used for Appliances	9188.6	78.8%

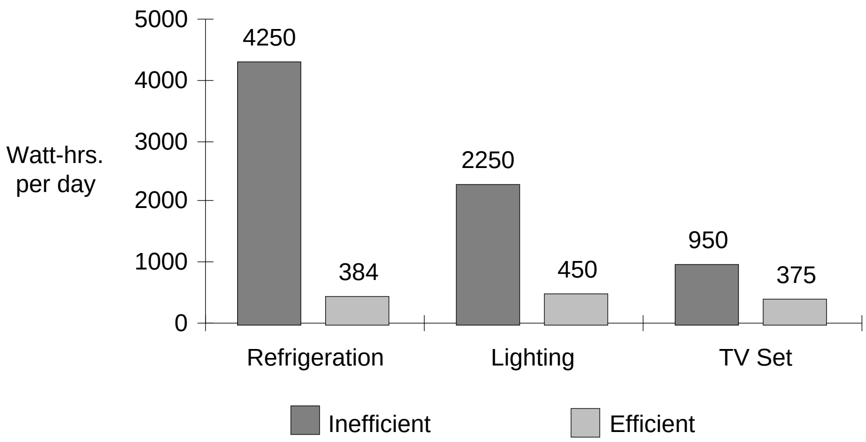
No.	Inverter Powered Appliance	Run Watts	Hours /Day	Days /Week	W-hrs /day	%
1	Refrigerator/Freezer	425	10	7	4250	33.1%
6	Incandescent Lights	75	5	7	2250	17.5%
1	21" Color Television Set	190	5	7	950	7.4%
1	Washing Machine	800	0.5	4	228.6	1.8%
1	Vacuum Cleaner	650	0.5	4	185.7	1.4%
1	Satellite TV System	60	3	7	180.0	1.4%
1	Power Tool	750	0.2	7	150.0	1.2%
1	Radiotelephone RX	6	24	7	144.0	1.1%
1	Clothes Dryer (motor only)	500	0.5	4	142.9	1.1%
1	Stereo	30	4	7	120.0	0.9%
1	Computer	45	6	3	115.7	0.9%
1	Video Cassette Recorder	50	2	7	100.0	0.8%
1	Telephone Answering Machine	4	24	7	96.0	0.7%
1	Microwave Oven	900	0.1	7	90.0	0.7%
1	Hair Dryer	750	0.2	3	64.3	0.5%
1	Food Processor	400	0.1	5	28.6	0.2%
1	Sewing Machine	80	2	1	22.9	0.2%
1	Blender	350	0.1	4	20.0	0.2%
1	Radiotelephone TX	20	1	7	20.0	0.2%
1	Ni-Cad Battery Recharger	4	15	2	17.1	0.1%
1	Computer Printer	120	0.25	3	12.9	0.1%
1	Phantom Load– Instant ON TV	30	24	7	720.0	5.6%
1	Phantom Load– Satellite LNA	22	24	7	528.0	4.1%
1	Phantom Load– VCR Clock	15	24	7	360.0	2.8%
1	Phantom Load– Stereo	10	24	7	240.0	1.9%
1	Phantom Load- Dryer Timer	8	24	7	192.0	1.5%
1	Phantom Load- Washer Timer	8	24	7	192.0	1.5%
1	Phantom Load- Microwave Clock	4	24	7	96.0	0.7%
1	Phantom Load– Computer	3	24	7	72.0	0.6%
1	Phantom Load– Computer Printer	3	24	7	72.0	0.6%

tag of your system or of your monthly utility bill.

For example, consider two sample Power Consumption estimates shown here. Both these systems provide the same electric-powered functions for a family of four. Let me be very clear about this– SYSTEM ONE and SYSTEM TWO both give the user the SAME utility.

System One represents using inefficient appliances and ignoring phantom loads. System Two represents effective electric power use and using phantom loads on switched outlets. Both systems use electric refrigeration, a washing machine, and many other appliances. Both systems provide the same function.

The Difference between Inefficient Appliances and Efficient Appliances



The efficient system delivers the same electrical service with four times less power consumption than the inefficient system. There are four major differences between these systems. System Two uses efficient refrigeration that saves over 3,800 watt-hours daily . System Two uses fluorescent lighting instead of incandescent light bulbs and that saves 1,800 watt-hours daily. System Two uses a TV with a smaller screen saving 575 watt-hours daily. System Two uses switched power outlets for the Phantom Loads saving 2,400 watt-hours daily. Bottom line is that giving System One an "efficiency job" will save enough power to run three more households just like System Two! The bargraph shows the difference between using inefficient and efficient appliances.

Efficient Appliances and No Phantom Loads

Total Watt-hours per day consumed	2947.6	%
Total Watt-hours per day for Phantom Loads	0.0	0.0%
Total Watt-hours per day used for Appliances	2947.6	100.0%

No.	Inverter Powered Appliance	Run Watts	Hours /Day	Days /Week	W-hrs. /day	%
6	Compact Fluorescent Lights	15	5	7	450.0	13.8%
1	Refrigerator/Freezer	48	8	7	384.0	11.8%
1	17" Color Television Set	75	5	7	375.0	11.5%
1	Washing Machine	800	0.5	4	228.6	7.0%
1	Vacuum Cleaner	650	0.5	4	185.7	5.7%
1	Satellite TV System	60	3	7	180.0	5.5%
1	Power Tool	750	0.2	7	150.0	4.6%
1	Radiotelephone RX	6	24	7	144.0	4.4%
1	Clothes Dryer (motor only)	500	0.5	4	142.9	4.4%
1	Stereo	30	4	7	120.0	3.7%
1	Computer	45	6	3	115.7	3.5%
1	Video Cassette Recorder	50	2	7	100.0	3.1%
1	Telephone Answering Machine	4	24	7	96.0	2.9%
1	Microwave Oven	900	0.1	7	90.0	2.8%
1	Hair Dryer	750	0.2	3	64.3	2.0%
1	Food Processor	400	0.1	5	28.6	0.9%
1	Sewing Machine	80	2	1	22.9	0.7%
1	Blender	350	0.1	4	20.0	0.6%
1	Radiotelephone TX	20	1	7	20.0	0.6%
1	Ni-Cad Battery Recharger	4	15	2	17.1	0.5%
1	Computer Printer	120	0.25	3	12.9	0.4%

The elimination of Phantom Loads from System One is a direct power gain. After all, these appliances are supposed to be off anyway. Using Phantom Loads on switched power outlets causes no loss in utility. If you want to operate the phantom, then just switch it on.

The Power Consumption Estimate

The power consumption estimate is just that– an estimate. Feel free to make changes after you have added everything up. A good place for changes is the large consumers of power. Note the difference efficient refrigeration alone makes between the two system examples. So examine how you use power. Every watt-hour eliminated is a watt-hour you and the environment don't have to pay for. Just to get ahead for a moment (this info really belongs in System Design), look at the hardware bill to put System One and System Two on photovoltaic power. The initial hardware investment for System One would be around $30,000., while System Two could be bought for about $9,000. Both systems deliver the same bang, but System One costs three times the bucks. This is a very good reason to be interested in using electric power efficiently.

And do it again…

After the information about your appliances is matched with your Site Survey and finally produces a

list of hardware via System Design– you will get an estimate of how much your system will cost. This cost is directly proportional to your power consumption. If you can't afford the system, then return to your power consumption. Eliminate inefficient and/or inappropriate appliances. Put Phantom Loads on switched outlets. Then design the system again to match the lower power consumption. It is not unusual to go through this process several times before actually installing or modifying a system. After all, planning and estimation is very cheap when compared to buying a rack of PV panels or a fleet of batteries.

So don't be afraid to change your electric appliances and how you use them.

Access

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The Basics– Site Survey

A site survey measures the renewable power potentials of a specific location. The natural sources may be solar, hydro, or wind. A site survey determines not only which sources are present at a specific place, but also accurately estimates the amounts of power offered by these sources. A site survey asks only two questions. What power sources are available? How much power is offered by the sources?

Marshalling your forces…

Site survey is not conducted in an office, but at the specific site. You cannot accurately survey a site for renewable energy potential without actually being there. And you must be accompanied the instruments necessary to make measurements.

The amount of time required for a site survey varies. In some cases, like solar and hydro, a site survey can be done in a few hours. Other sources, like wind, will require several months, or even years, of measurement before accurately estimating the source's power potential.

So put on your knee-high rubber boots and let's do some site surveying.

Surveying for Solar Power

A good solar site is easy to recognize. It is the not–so–good sites that are difficult to survey. What every solar system needs is ALL THE SUN IT CAN GET. A good solar site sees the Sun come up at Dawn and go down at Sunset. A good solar site faces SOUTH. A good site directly sees the Sun all day and is unobstructed by mountain ridges, hills, trees, or buildings. If your site has dawn to dusk direct sunlight, then you're in and need to survey your solar no further. All you need is an accurate compass to face your PV array directly SOUTH. Be sure to figure in the difference between magnetic North and true North for your location. This difference between compass North and real North is known as "magnetic declination". For example on the West Coast of the USA, magnetic North is about 19° East of true North. Check a topographic map of your area if you don't know your local magnetic declination, it's printed on the map.

While all day sun is what we all want, few sites actually have totally unobstructed access to direct solar radiation. Then solar site survey becomes a war of attrition. Each obstacle preventing the Sun's rays from directly falling on the solar face must be located and its effects quantified.

Exact placement of a PV array is critical. Move the array a few feet and the yearly total amount of solar radiation changes. Determining exactly how much solar energy a specific location receives throughout the year is not easy. And to further complicate things, the Sun's angle keeps changing with the seasons. This means that obstacles that don't shade the array in the Summer may do so during Winter.

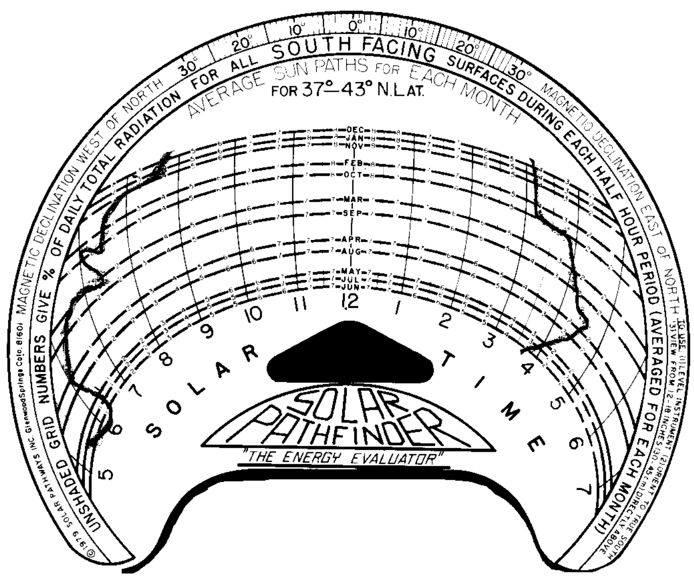
The array needs to be located at that one specific place on a site that receives the most sunshine. The Solar Pathfinder is THE tool for this job. It takes all the guesswork out of predicting how much sunshine the array will receive, at a specific site, throughout the year. The Solar Pathfinder is easy to use and accurate enough to measure changes in array position down to a few feet.

The Solar Pathfinder

The Solar Pathfinder uses a highly polished, transparent, convex plastic dome mounted on a platform containing a compass and a bubble level. Reflected in this dome, the user sees a panoramic view of the world around him. All the obstacles to direct sunshine are plainly visible as reflections on the Solar Pathfinder's polished dome. Since the dome is transparent, the user can also see the sun chart within the Solar Pathfinder. This chart shows details of the Sun's path for every month of the year. The sun chart is also calibrated by the hours of the day.

The dome has slots in its sides and the user traces the outline of the horizon's reflection on the dome onto the sun chart. The traced line shows exactly at which hours of the day, and months of the year, that an obstacle will shade the PV array. From this information we can predict the array performance at any time of the year. The Solar Pathfinder can be used anytime of the day, anytime of the year and in either cloudy or clear weather. In fact, we found it easier to see the reflections in the dome when it was overcast, at dawn, or at sunset.

We ran sun charts for many different locations around our site and compared the amount on sunlight received at each. By doing this, we were easily able to select the best place to put our ground-mounted array. And I mean down to the last foot! No guesswork, no "Well, it looks to me…", just the straight and accurate facts. Shown below as an example is the sun chart of our PV array's site at Agate Flat.



Cost for the Solar Pathfinder is $149. shipping prepaid in USA. This includes a metal case, tripod, an instruction manual, and sun charts. Considering that PV arrays can cost thousands of dollars, the Solar Pathfinder is inexpensive because you can put the array in the just right place to get its maximum yearly power output. The maker of this instrument is: Solar Pathways Inc., 31 Chaparral Circle, Glenwood Springs, CO 81601 or telephone 303-945-6503.

Cloudy Days

What the Solar Pathfinder doesn't tell you is how many cloudy days you have. Or when these cloudy days occur. Or exactly how cloudy those cloudy days are. Or the duration of intense cloudy periods. Or the duration of sunny periods between the cloudy periods.

The only real way to determine these parameters accurately is to run a recording solar pyrometer or a recording Ampere-hour meter for several years and tabulate the data. Well, the National Weather Service does exactly that for the specific locations where it has weather offices. Solar insolation data is available from the Federal Govt., State Agricultural Agencies, and from local airports. This data is highly site specific. For example, our local weather office is located at the airport in Medford, Oregon. Medford is located at the bottom of a deep valley and is famous for its fog (and air pollution). The Medford airport is closed many Winter days and aircraft traffic is diverted elsewhere. In the hills above Medford, the Sun is shining on many PV panels, but the official record is recording dense fog. Official Weather Service Data is site specific. If you live in the mountains, or on the seacoast, then your specific site will almost certainly receive a different amount of solar insolation. So take the official data with a grain of salt and allow for your local microclimate.

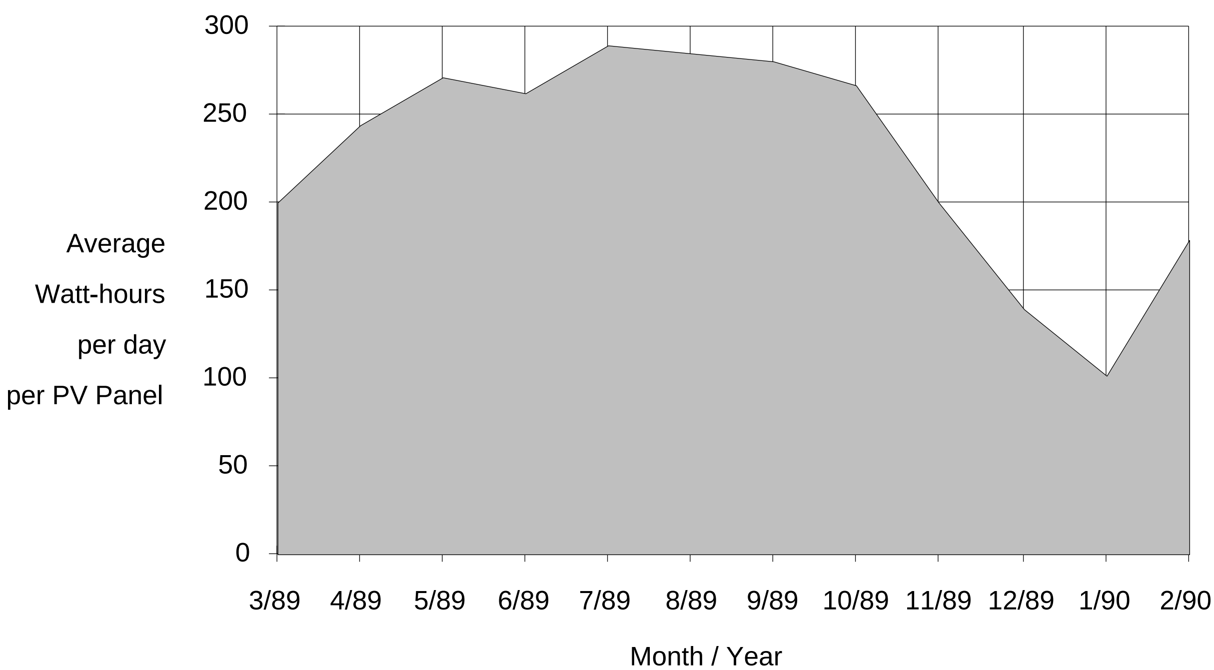
If you can't trust the government, then who can you trust? You can trust your neighbors. Especially, if you have a neighbor with an array, some instrumentation, and smarts enough to write down the data. If you can't locate a solar techie in your microclimate, then ask an old timer. For the sake of clarity, define a cloudy day as one when you can't see your shadow. Here's what you need to know in order of importance. How many consecutive days is it cloudy? What is the average number of days between cloudy periods? How many days are cloudy during the year? At what time of year do the cloudy periods occur?

All evidence from non–solar–techie–neighbors is strictly hearsay, not admissible in a court of law, and should be treated as such. So, once again, add a generous grain of salt and allow a wide margin for error if you use hearsay data.

Knowing the Unknowable…

So that you'll know that this information is real, here's what we have determined by actual measurement of PV performance at our site in Agate Flat, Oregon. If you look this place up on a map, you find find a blank space. That's why we moved here. Anyway, we've been writing down the daily data supplied by a Thomson and Howe Recording Ampere-hour meter connected with our PV array since late 1988. So we have accumulated over two years of very site specific PV performance data. Below is a chart showing the average daily power output of a single PV module located at our site. This chart covers an entire year from March 1989 to February 1990. Taking this kind of data allows me to very accurately estimate the average daily power production of a PV module at our location. A forty-eight Watt module will produce an average of 226 Watt-hours daily at my location. Since this data is derived by a year's worth of actual measurement, it takes into account any cloudy weather during the period.

Average Daily Power Output, in Watt-hours, of a 48 Watt PV Module located at Agate Flat, Oregon • 42° 01' 02" N. 122° 23' 19" W.



The Importance of Solar Insolation Data

The amount of sunshine you get determines the number of PV modules you will require to supply your power needs. The number of consecutive cloudy days will determine the size of the battery you will need to store your power. The more accurately you know your site's solar insolation data, the better you can eventually specify the hardware you will need.

If you don't want to survey your site or root out the local solar data, then hire someone to help you. The very minimum that every PV system needs is a sun chart produced by the Solar Pathfinder or other solar estimation device. If you have to pay someone a hundred bucks to visit your site with a Solar Pathfinder, then it is money very well spent. If it saves you from buying even one unnecessary PV module, then a site survey pays for itself three times over.

Access

Author: Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 914-4753179.

Surveying for Hydro Electric Power

Shortly after men climbed out of the trees and started using tools, they discovered that moving water's power could be harnessed to make things happen. Using the kinetic force of water is called "hydro power" Hydro power was quickly adapted from mechanical uses, such as grinding flour in a grist mill, to spinning a generator to produce electricity. Before the Rural Electrification Administration (REA) came into being, there were thousands of small hydroelectric plants powering farms, residences, and small communities. We are starting to realize (if not actually paying for it yet) the real cost of large-scale power production and transmission. Micro-hydro sites are once again being developed and utilized.

The Site survey

Do I have a site suitable for hydroelectric power production? To answer that question, we have to examine four factors.

1. The distance of Head or vertical fall that the water source develops.

2. The amount of water (usually expressed in Gallons per Minute or GPM) available for generation

3. The length of pipe needed to go from the water source to the hydroplant.

4. The distance from the hydroplant to the electrical load, whether that be storage batteries, or in the case of AC generation, the appliances themselves.

Given these four factors, we can determine not only if hydroelectric power generation is feasible, but which diameter of pipe is needed, which type of the available hydroplants to use, and approximate output and costs.

Head

There are three basic ways to measure Head or vertical fall.

Site Level method: Tools for this method range from a carpenter level and a couple of sticks, to an Abney type site level, to an expensive surveyor's transit & tripod. All three tools use the same method. Start at the water source or intake to the pipeline and proceed downhill using two people. The uphill person or sighter, using the level and a short stick or tripod, sites downhill to the second person,or target holder, who is holding a long stick or target rod. Marking the point on the target rod that the sighter determines is level with his tool, the target holder measures the distance from the mark to the ground and subtracts it from the length of the sighter stick or tripod holding the surveyor's transit. This yields the net head or vertical fall in the distance or station between the two surveyors. The sighter then moves down to the exact position of the target, the target moves downhill, and the process is repeated until the target reaches the proposed hydroplant site. Adding the net heads from each station yields the total Head in the run.

Hose method: Starting at the highest point with two people. Use a length of hose is laid out with one end at the intake and the other trailing downhill. Fill the hose (getting all the air out) and have the downhill person elevate the hose JUST until the water stops flowing. Measure and record the distance from the hose end straight down to the ground. Both parties then put their thumbs over the hose ends and walk downhill until the uphill person gets to the exact position where the last measurement was made. Repeat the procedure until the proposed hydroplant site is reached and add all the findings. It's necessary to top off the hose a little each time, so if you're not following a live stream course, the uphill party should carry along a jug of water for this purpose. This method has the added advantage of measuring the total length of pipe needed in the system by just multiplying the length of the hose by the number of stations.

Pressure Method: This is the easiest method of all. The pressure method assumes that the water system (or at least the pipeline) is already existing and that you have a a pressure gauge. Make sure that the pipeline is full and all outlets are turned off. Attach the pressure gauge to an outlet at or near the proposed hydroplant level. Take a reading and multiply the PSI X 2.245 to find the Head in feet.

Measuring Water Flow

Up to 75 GPM or so, which accounts for most hydrosites by far and away, the easiest way of measuring flow is the pipe and bucket method. You'll need to construct a temporary dam of sorts at the water source. Fit a short length of pipe large enough to handle all the water you plan to use for generation into the dam. Using a bucket of known capacity and a stopwatch, time how long it takes to fill the bucket. Repeat several times to determine that your technique is accurate. The formula is; GPM=bucket capacity / (#of seconds to fill bucket X 60).

Access

Bob–O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3401.

Surveying for Wind Power

Off all the renewable power sources discussed, a potential wind site is the most difficult to survey. In addition, a thorough survey of a wind site is essential before specifying or installing the turbine.

Your Fuel is Wind

The power produced by a turbine depends on how fast the wind is blowing. Wind power is measured in terms of speed. The higher the wind speed, the greater the potential output power you may expect from a wind turbine.

The power available from the wind is proportional to the cube of its speed. For example, assume that a turbine produces 100 watts in an 8 mph wind. At 16 mph this same turbine will produce over 800 watts. Doubling the wind speed increases power available by a factor of eight times. A very small change in wind speed translates to a big increase in available power. Small differences in your site's annual average wind speed determine whether or not your site is a cost-effective candidate for a wind power.

Average wind speed is the critical factor that determines the economic effectiveness of wind machines.

Rough and Ready Wind Speed Estimation

Let's look at some easy methods of determining wind speed. If you have lived for several years at a site, then you probably have some idea of your site's average wind speed. For instance, how many days per week does the wind raise dust, extend flags and streamers, or blow paper and cardboard about the yard. These winds are usually in the area of 8-12 mph. Another good indicator of average wind speed is trees or shrubs permanently deformed in the direction of the prevailing winds. An average wind speed of at least 10 mph is needed to cause permanent deformation in vegetation. If your site exhibits these characteristics, then perhaps further investigation is warranted. If you don't have a site that

could be described as windy, based on these observations, then consider an alternative to wind power.

Using a Recording Anemometer

If you feel your site is windy, and you are serious about installing a wind turbine, then install a recording anemometer. In some areas, a check with the local weather station might be sufficient to determine average wind speeds. Wind data from airports is not very applicable to wind power sites because airports are intentionally located at sites with minimum winds. Don't consider wind power without a thorough measurement of the wind speed at your specific location. In most cases, four months should be the minimum recording interval and one year is preferred. If you are going to spend a lot of hard earned money on a wind system, this extra eight months could mean the difference between a good investment and a bad one.

Proper Tower Placement

Although a recording anemometer is a very accurate instrument, its output information will be accurate at a specific location. In areas of rolling hills or tree cover, the wind speeds can vary 30% or more between sites only 100 feet apart. The location of an anemometer on a specific site, as well as height above the ground and any obstruction, is critical to recording the highest winds available. On level land with no nearby obstacles, a 40 foot tower should be the minimum height for your anemometer or turbine. It is essential to measure wind speed at the actual height you plan on installing your turbine. Obstacles or short towers are only robbing you of power. If you are considering placing your turbine on a hill to gain wind speed, place the turbine high enough on the hill to enter the smooth undisturbed wind stream.

Installing a wind turbine is not a matter of simply erecting a tower and putting a generator on top. Only through accurate wind speed data on your particular site can you hope to install a wind system that is capable of supplying the power you need.

Larry Elliott

Specifying Wind Systems

Editor's Note: The following wind survey concept arose between Mick and I during a phone conversation. It bears so much relevance that I have included it here. RP.

Alternatives to a Recording Anemometer

Average Wind Speed

While average wind speed is meaningful, there are other wind parameters that are just as meaningful. Other wind parameters worth knowing are maximum wind speed, number of days (hours) between winds of greater than 10 mph. Number of consecutive days (hours) where the wind is in excess of 10 mph, and the times of year where the either wind or not wind periods occur. All this data is not available from garden variety recording anemometers.

A recording anemometer that will take all the data mentioned above will cost a bundle. Such anemometers are more computer than wind sensor and cost between $2,000 and $4,000. I offer the following alternative.

Install a Small Wind Machine

For the cost of a detailed recording anemometer, you can install a working small wind machine. Consider that a Whisper 1000 or a Windseeker can be installed at about the same cost as a sophisticated recording anemometer. With the addition of an accumulative Ampere-hour meter (about $200), this setup not only provides real and hard data about wind powered electric generation, but also supplies power at the same time.

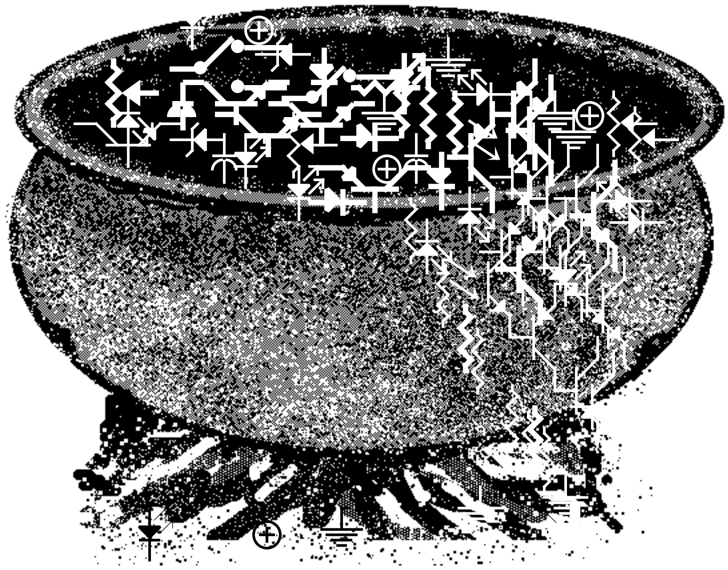
What if I don't really have a site suitable for wind?

It is much easier to sell a working wind machine than a sophisticated recording anemometer. If your site turns out not to have appreciable wind power potential, you can more easily get your money out of a wind machine. If your wind site has potential, then you have a great head start on your wind electric system.

Access

Mick Sagrillo, Lake Michigan Wind and Sun, 3971 E. Bluebird Road, Forestville, WI 54213 • 414-837-2267.

Homebrew



Build a Time Machine

Richard Perez

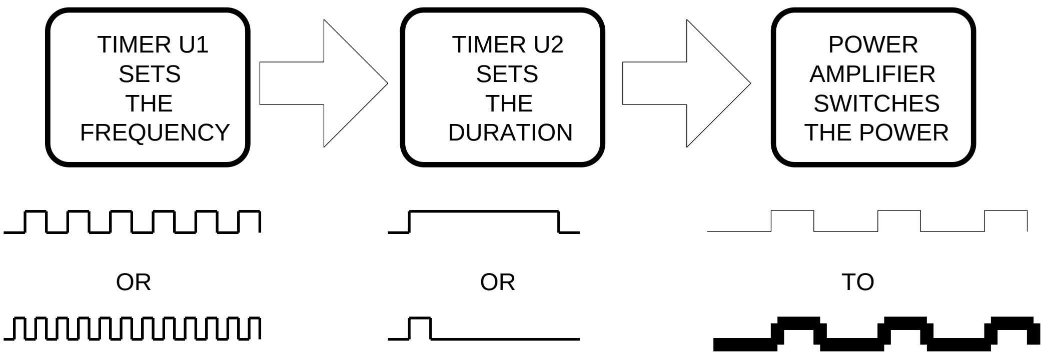
This electronic device is a time machine. It makes precisely timed pulses of electricity. The pulses can occur as often as you wish and last for as long as you wish. Some of the many applications for this device are: a super efficient 12 VDC motor speed controller, an high efficiency electronic rheostat for DC power control, and an electric fence charger that keeps pesky critters where you want them. All of this and more from precisely timed electronic switching!

A Time Machine?

You bet. This circuit uses two NE555 electronic timers to make custom tailored pulses of electricity. The first NE555 timer, U1, is operated astable as an oscillator, or in techie lingo– a multivibrator, or in nerd terms– a flip-flop. U1 determines how often the pulses occur. There could be one pulse every ten seconds or thousands of pulses per second. The second NE555 timer, U2, determines the amount of time that the pulse spends ON, or in other words, the duration of the pulse. U2 is operated as a slave to U1. U2 only emits a pulse when U1 says to do so. U2 is operated in monostable mode, as a "one-shot" multivibrator. The pulse produced by U2 may have a duration of seconds, or may have a period as short as microseconds. The resulting pulse train is fed to a power amplifier that switches the load. And that's the whole point of this device, chopping electricity into pulses in order to control power.

THE TIME MACHINE

using precision pulses to control power



So who needs pulses?

Using pulses of electricity can solve many power control problems in 12 VDC systems. For example, consider controlling the speed of an electric motor. The most common method of controlling 12 VDC electric motors is to insert a resistor in series with the motor. This indeed limits the motor's speed by reducing the amount of power available to the motor. It also wastes gobs of power in the resistor.

Another way of controlling the motor is to rapidly switch its power ON and OFF. The major advantage switching is a vast reduction in power consumption. When the electronic switch is OFF, then virtually no power is used. In this switching scenario, the amount of power the motor uses is proportional to its speed. The slower the motor rotates, the less power it uses. Compare this to the resistor power control method where power consumption remains relatively constant regardless of motor speed.

Notes on the Time Machine

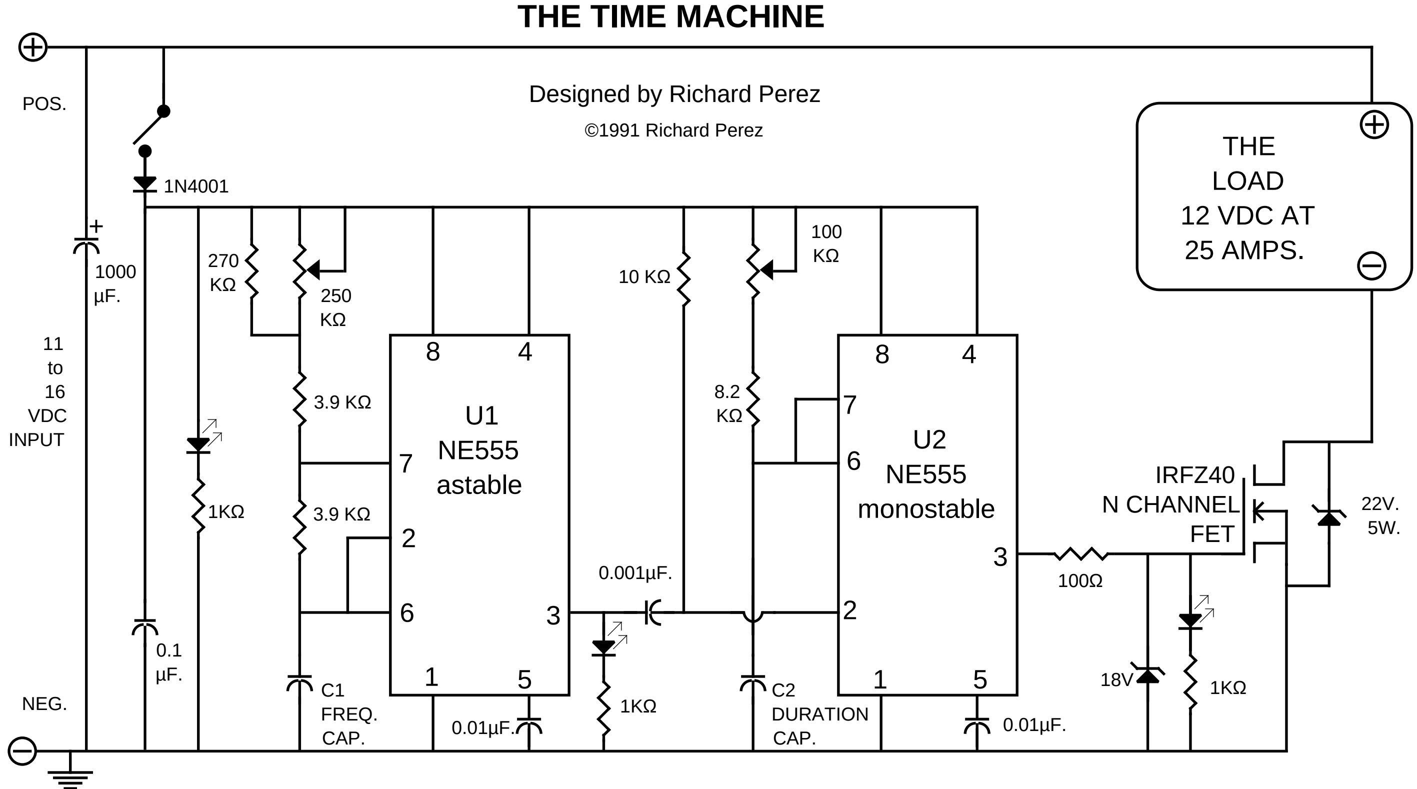
C1 is the timing capacitor for U1, the astable multivibrator. Increasing the value (amount of capacitance) of C1 will decrease the frequency of the pulses that the Time Machine produces. C2 is the timing capacitor for U2, the monostable multivibrator. Increasing the capacitance of C2 will result in pulses of longer duration. The table below shows the values for C1 and C2 and the resulting timing parameters for this circuit. Since the NE555 uses a resistor/capacitor timing chain, these times versus values for C1 and C2 are correct only for the resistor networks shown in the Time Machine's schematic. If you vary the resistors in the NE555 timing chains, then the time parameters (frequency and duration) of the resulting pulse will also change.

Power control often requires custom tailored pulses. Consider that the pulses used for motor speed control need to be synchronized with the rotational dynamics of the motor. And consider that these rotational dynamics change with the type of motor, the number of poles within the motor's windings, and the motor's speed. That is why the Time Machine shines. It can provide whatever pulsation is required.

Flying the Time Machine

The timing chains of both U1 and U2 contain potentiometers. By adjusting these potentiometers, the timing parameters of the resulting pulses changes. If you use the specified

THE TIME MACHINE



TIMING CHART
values of C1 and C2 for the Time Machine

PULSE FREQUENCY	C1 or C2 in µF.	PULSE DURATION
10 kHz. to 100 kHz.	0.001 µF.	10 µs. to 100 µs.
1 kHz. to 10 kHz.	0.01 µF.	100 µs. to 1 ms.
100 Hz. to 1kHz.	0.1 µF.	1 ms. to 10 ms.
10 Hz. to 100 Hz.	1.0 µF.	10 ms. to 100 ms.
1 Hz. to 10 Hz.	10 µF.	100 ms. to 1 s.
0.1 Hz. to 1 Hz.	100 µF.	1 s. to 10 s.

resistor/potentiometer networks shown in the schematic, then your Time Machine will produces pulses as per the Timing Table shown above. This means that the pulses can occur as slowly as very ten seconds (0.1 Hz.), or as rapidly as one hundred thousand times per second (100 kHz.). This also means that the pulse can last as long as ten seconds, or as short as ten millionths of a second (10 µs.). And this covers the frequency and pulse duration ranges needed to efficiently control even the most odd-ball DC motor. The same approach to time related power control can be applied to 12 Volt incandescent lighting, recharging small and large batteries, and even driving transformers to produce higher voltages.

The Timing Capacitors

If you know the range of frequency (C1) and the range of pulse duration (C2), then you can select the appropriate timing capacitors for each function. The potentiometers allow you to fine tune the Time Machine within the timing ranges of the selected capacitors. I built several models of the Time Machine with six pole rotary switches that select the appropriate capacitor for for C1 or C2. I used Radio Shack two-pole, six position, non-shorting rotary switches (RS #275-1386). This allows the Time Machine to produce all the frequency and pulse duration ranges on the table without resoldering capacitors to the circuit. I didn't include the rotary switches in the schematic because they are not required for operation and complicates the device for dedicated applications. If you are building the Time Machine for experimentation, or if you don't really know what frequency and duration ranges you require, then use the rotary switches and install all the capacitors.

Use tantalum or polystyrene capacitors as C1 and C2 if you can get them. Disk ceramics will work OK, but are not as stable. Use electrolytic capacitors for the 1µF., 10µF., and 100µF. timing capacitors.

Other Time Machine Components

The two NE555 timers produce the pulse train which is fed form pin 3 of U2 to a semiconductor acting as a switch. Over the years I have built Time Machines with every sort of power output design imaginable. The output network using the IRFZ40 works very well and will transfer 50 Amperes of current. The IRFZ40 is an International Rectifier HEXFET®, N-channel, Field Effect Transistor rated at 125 Watts, 50 Volts, 51 Amperes continuous at 25°C., and surge to 160 Amperes. The IRFZ40 comes in a standard tab mounted TO-220 case. This amazing FET has an ON resistance of 0.028Ω, and that's low enough to switch prodigious amounts of current with heating up the FET. The output section using the IRFZ40 is negative leg processing. Note that the load is hardwired to positive and controlled via switching its negative line. This works well in most applications and allows the use of inexpensive, high-current FETs. However, the IRFZ40 will not survive a direct short circuit of its output. I've blown up several during R&D and by mis-wiring. However, once installed and operating I have never had one fail.

I got my IRFZ40 from Digi-Key, 701 Brooks Ave. South, Thief River Falls, MN 56701-0677 • 800-344-4539. They sell the IRFZ40 for $6.12 each or for $36.75 for ten. Digi-Key has a $5.00 surcharge on orders under $25.

All resistors are 1/4 Watt unless otherwise noted. All capacitors are 25 Volt rated minimum and 50 Volt is better. All LEDs are optional, but they look pretty flashing away. Also, they provide information about the operation of each of the Time Machines timers.

Using the Time Machine

Use it where you can control power via switching. I have recharged a six volt car battery from my 12 Volt system using the Time Machine. I have recharged all variety of lead-acid gel cells and small nicad cells using the Time Machine. I have controlled the speed of brush -type DC motors, up to 1/2 horsepower. I have pulsed the input of transformers to provide high voltage for applications like fluorescent light tubes. That's right, the Time Machine's pulses can operate transformers and produce a variety of voltages. I even set the Time Machine at 60 Hz, and pulsed a transformer to produce 60 Hz., 120 Vrms, square-wave alternating current,creating a rough–and–ready inverter.

The utility of the Time Machine is limited only by the user's imagination. For example, consider its specialized application as an electric fence.

An Electric Fence is Born!

Nine years ago, we faced a serious equine problem. Karen's horse, an intelligent and sometimes foolhardy Arabian mare named Oozie, kept escaping. She had no respect for barbed wire. Oozie's two pervious encounters with barbed wire resulted in serious cuts, on-site visits by the Vet, and much of Karen' gray hair. We really needed to keep the horse in her 35 acre pasture without allowing her to injure herself on barbed wire.

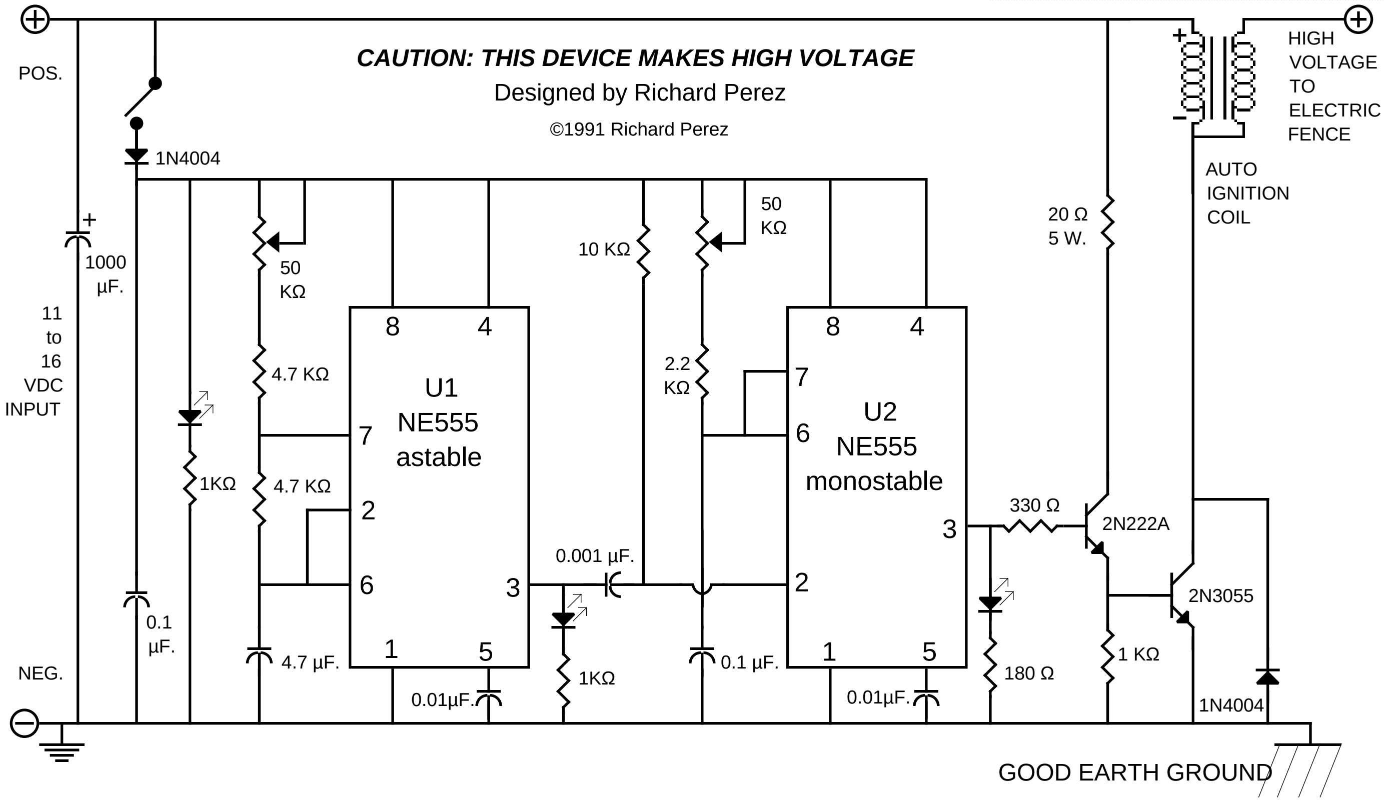
Karen installed over one mile of electric fence to corral her horsie friend. We went to town and bought a commercial electric fence charger powered by a car battery. This did the job. High voltage electricity made a believer of Oozie where the barbed wire failed. And best of all- no more barbed wire cuts. Everyone was happy until the fence charger broke.

The first fence charger lasted about two months and died. We bought another and it lasted about three months. With both chargers, I was far from pleased with their high power consumption. The car battery would last only about three weeks before being totally discharged. These electric fencers were not built to last and they were power pigs. There had to be a better way.

I remembered my Time Machine. I considered that an automotive ignition system used switched pulses into the ignition coil to produce high voltage. I set about adapting the Time Machine as an electric fence charger. Since I didn't want to wind my own coil, I just used an old automotive coil I had on hand. The circuit is a specific adaptation of the Time Machine and its schematic follows below.

The only major difference between the Electric Fence and the Time Machine is the output amplifier. The Electric Fence uses a two

ELECTRIC FENCE



stage silicon power amplifier using a 2N2222A and a 2N3055 bipolar transistors. I used this design because it is very rugged and will survive the incredible high voltage transients that accompany electric fences. This design has been running here at Agate Flat since 1982, and for many of my neighbors since 1985. It works efficiently (average current drain is about 3 Amp-hours per day) and has survived all variety of lightning storms. The exact automotive ignition coil you use is not important. I have used everything from a six volt VW coil to a high energy 12 Volt coil from a late 1970s Ford. They all work well enough, producing over 20,000 volts on the fence.

In order to function properly every electric fence needs a good ground. Consider several grounding rods if your soil is dry. Drive the rods as far as you can into the ground and use at least 8 gauge wire between the charger and the ground rod.

Using the Electric Fence

U1 controls how often the pulses of electricity occur on the fence. Using the resistors on the schematic the pulses can occur as often as about 50 pulses per second and as infrequently as one pulse every two seconds. If you are training livestock to an electric fence, then keep the frequency high. After the livestock is wary of the fence, turn the frequency down and save power. U2 controls the amount of power contained within the pulse. You can adjust the amount of power to suit your ground conditions (dry ground has higher resistance and requires more power). I turn our fence up during the Summer and down during the Winter. You can adjust the power to suit the length of your fence. We've charged up over five miles of fence in dry conditions. If you adjust the amount of power, then you will consume no more power than you need. BE CAREFUL HERE! Karen once disconnected the majority of our electric fence and I forgot to reduce the Electric Fence's power output to compensate. Oozie got across the super-hot fence and the shock knocked this 1,000 pound horse off of her feet. She spent the next few hours not feeling at all well. So, listen up, here comes the caution notice!

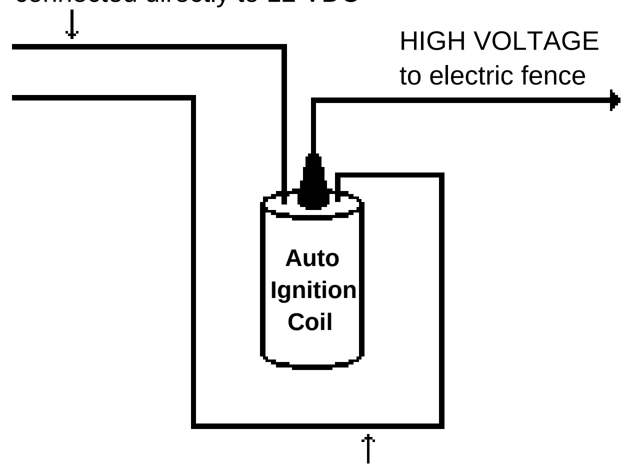
CAUTION:

THIS ELECTRIC FENCE MAKES

HIGH VOLTAGE!!!

The basics of safety apply here. Don't let your body get between the high voltage output of the coil and ground. I did this once and it

Battery terminal on the Ignition Coil is connected directly to 12 VDC



Distributor terminal on the Ignition Coil is switched by the Electric Fence

knocked me across the room. Turn the fence OFF if you are doing repairs. Don't grab ahold of the fence if you are wearing wet boots, no shoes, or are otherwise grounded. It will shock you. The pulse emitted by the Electric Fence is high in voltage, but limited in power because the pulses duration is very short (a few milliseconds). While many critters and a few foolish humans have tangled with the fence and gotten shocked plenty, no lifeform has been really injured. We have noticed that this Electric Fence will kill weeds that touch it. This is great because vegetation across the fence will short it out and render it inoperative for shocking livestock. Since the amount of power is controlled and low, the Electric Fence will not burn these weeds, hence no fire danger.

ACCESS

Author: Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

Time Machine parts: Those interested in mil-spec glass-epoxy, pre-drilled printed circuit boards for the Time Machine should contact Bob-O Schultze at Electron Connection, POB 203, Hornbrook, CA 96044 or call 916-475-3401. Bob-O also has completely assembled and tested models of the Electric Fence and Time Machine. Contact him for specifics.

Above: Karen and her friend, Oozie, discuss electric fences. While Oozie is a notorious escape artist, the electric fence keeps her where she should be.

Build a Constant Current Source

Jeff Damm

The best way to recharge Nickel-Cadmium batteries is with a constant current source. My motivation for designing the circuit in this article was that I wanted a variable current source which had the flexibility to charge a variety of different size "NiCads". I also wanted it to be reproduced easily and relatively inexpensive. Many hours of tinkering finally produced the circuit shown in figure 1.

Figure 1 is a schematic of the components required to make an adjustable constant current source from readily available components. Charging a battery with this circuit is accomplished by placing the circuit between a positive voltage source (or current source, i.e. a PV panel) and the positive terminal of the battery to be charged. The amount of charging current is set with R2, the 10k potentiometer. The current is linearly variable between essentially zero amps and up to 1 amp. More current can be obtained by lowering the value of the 1 ohm sense resistor.

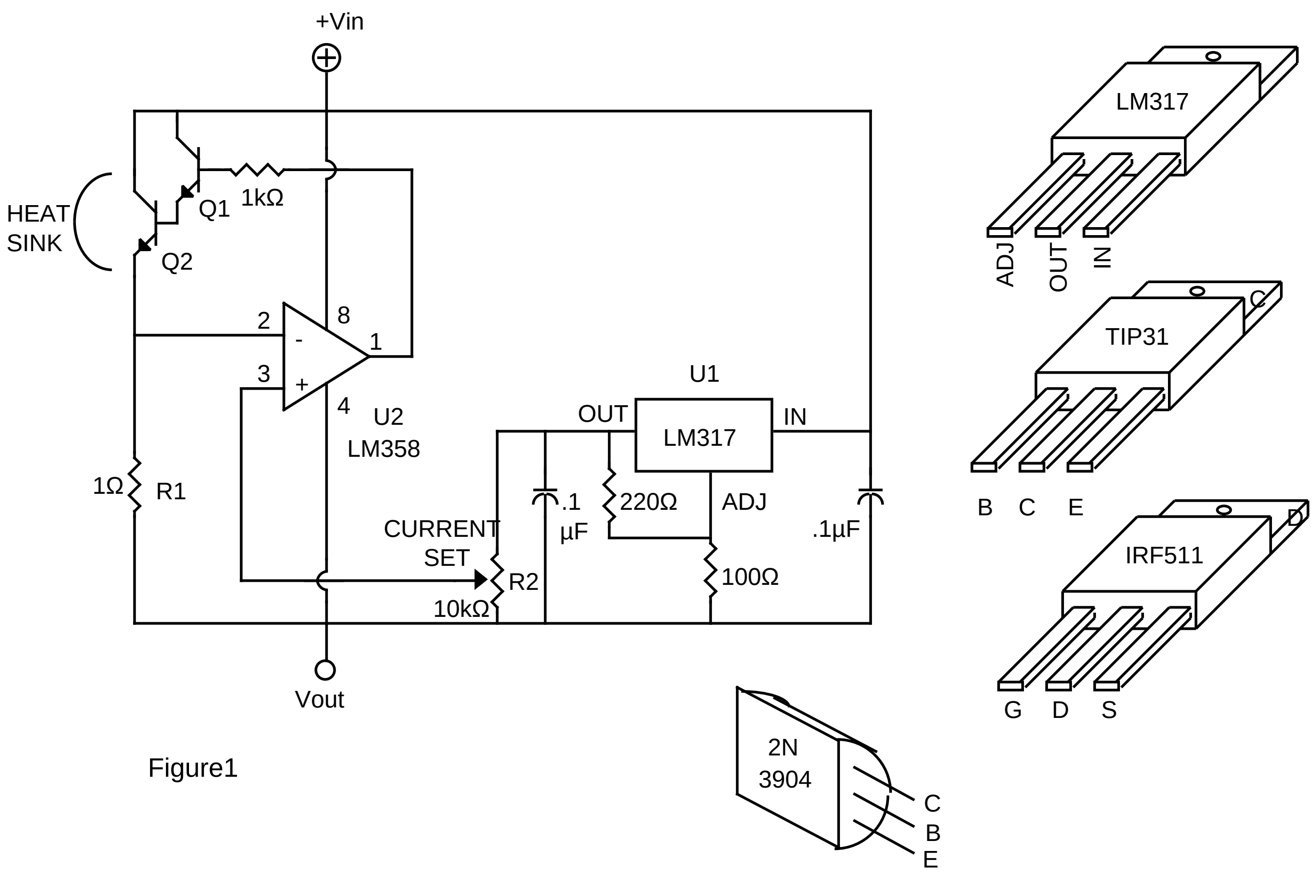


Figure1

This circuit operates by using operational amplifier (opamp) U2 to sense the voltage across the 1 ohm resistor and comparing it against the voltage on the wiper of potentiometer R2. The opamp output voltage will adjust itself to a voltage that will generate the correct current through transistors Q1, Q2 and R1, the 1 ohm resistor, in order to make the voltage difference between the opamp inputs (pins 2 and 3) go to zero. Q1 and Q2 operate as a Darlington emitter follower driven by the opamp. The LM317 voltage regulator has been programmed for a fixed output voltage of about 1 volt. The 10k pot simply provides a voltage divider action to supply a 0 to 1 volt reference relative to the circuits "output rail".

The LM317 does not draw very much current, so it can be replaced by it's lower current relative, the LM317L. I like the L version since it comes in a TO-92 package.

I used a 2N3904 for Q1, although just about any small signal NPN transistor will work well for Q1. A popular alternative would be the 2N2222A.

I tried many different transistors for Q3. The following devices produced supply thresholds of about 3.5v at 100mA: MJE1102, TIP50, TIP52, 2N3923 , 2N2219A, 2SC2527, TIP31, and TIP3055. The supply threshold is the minimum voltage across the circuit in order to produce the selected constant current. A TIP120 is a Darlington pair in a single TO-220 package that performs the function of both Q1 and Q2 together. The TIP120 showed no performance difference compared to the other device combinations. All of the TO-220 case devices used for Q2 are capable of much more than 1 amp. The collector current capability of Q2 and the power dissipation rating of R1 will be the limiting elements in determining the maximum current handling capability of the circuit.

The LM358 opamp is essentially half of an LM324 quad opamp.

The LM324 should work just fine as a substitute for the LM358. I have not tried the LM741 opamp yet, although it ought to work also. The LM741 may not provide a low enough output swing to turn Q1 and Q2 all the way off.

One feature of this circuit is that the builder can monitor the voltage across R1 or the voltage on the pot wiper in order to determine the actual current flowing into the load. The 1 ohm resistor provides a 1 volt per amp terminal voltage. This means that the user can monitor the current with a DVM and get a direct output in amps on the volts scale without the need to break the circuit and insert the DVM in amps mode. Another feature is that current can be monitored with a built–in analog voltmeter built from a small 1 mA. or less meter and a series pot (100k) and set the voltage range to accommodate any error in the actual resistor value. This also means that custom meter shunts do not need to be built and calibrated. A pot is very easy to adjust and leave set, on the circuit board.

This circuit was built and evaluated using "ugly" construction techniques. All parts were built on a small piece of copper circuit board. No holes or etching was necessary. The parts were simply suspended off the board by the components that shared the output node. Wiring is not critical and no instabilities were observed.

A heat sink on Q2 will be necessary for currents beyond about 100mA. If Q2 operates too hot to keep your finger on it, then it needs a heat sink.

All resistors (except R1) were 1/4 watt rating. If your junk box does not provide the necessary parts, Radio Shack does stock the TIP120, TIP3055 and the TIP31. It should also be noted that some RS stores do not stock all "catalog" items. Some RS stores stock items that are not in their catalog. The entire circuit should cost less than $10 (US) if all the parts are purchased new. This constant current source will provide the user with a single circuit that is capable of charging AA,C,D and F cell NiCads at whatever rate you want to safely employ. I have also had good results with this circuit charging gel cell sealed lead acid batteries.

ACCESS

Jeff Damm, 6565 S.W. Imperial Dr., Beaverton, Oregon 97005 • 503-646-4217

H A P P E N I N G S

The Solar & Electric 500

The Solar & Electric 500 is the focal point of a three-day event, sponsored by the Solar & Electric Racing Association. The event will be held April 5, 6, & 7 1991 at the Phoenix International Raceway in Phoenix, AZ. The highlights are:

THE SOLAR 300 - Exotic, lightweight experimental racers, powered only by the sun, race 150 kilometers Saturday, April 6th, and the final 150k Sunday, April 7th. Entries, including some from major auto makers, are expected from all over the world. Held on the one-mile oval. Qualifying and world-record runs are Saturday.

THE ELECTRIC 200 - This electric Stock Car race, covering 200 kilometers, or 124 miles with a two-hour time limit, features street-registered stock automobiles with electric power plants, and prototype electric stocks from auto makers around around the world. Held on the one-mile oval. Qualifying and world-record runs are Saturday.

EXHIBITOR TRADE SHOW - A manufacturers' midway of exhibits by companies who make, market or support all kinds of clean-air and alternate fuel products, technologies and services. The exhibit area is located outside the main grandstand.

RIDE & DRIVE - fans, members of the media and everyone interested in new clean-air, alternative vehicles can go "car shopping" -ride in or test drive - these exciting new vehicles. Held on the separate 1 1/4 mile test track outside turn two of the one mile oval.

For more information contact, Solar & Electric 500, Ernie Holden, 11811 N. Tatum Blvd., Phoenix, AZ 85028, 602-953-6672, Fax 602-953-7733

Appropriate Technology Associates

Appropriate Technology Associates (ATA) announces the formation of the Solar Technology Institute of Colorado (STI). The Institute's purpose is to be an educational and technical resource for solar energy. Summer one and/or two week intensive 'hands-on' workshops are:

Photovoltaic Design and Installation, July 8 to 19 in Colorado. Solar Energy for the Developing World, August 5 to 9 in California. Solar Technology for Rural Health Care, August 26 to 30 in Colorado.

The '91-'92 Solar Home Program (Sept. -May) will offer a how-to and hands-on series of workshops. Learn to design and build

state-of-the-art solar homes that are self-reliant, thermally efficient, healthy to live in and environmentally conscious. For detailed schedules and descriptions, costs, and scholarship information write, Solar Technology Institute, POB 1115, Carbondale, CO 81623-1115 or call Ken or Johnny at 303-963-0715.

Independent Power & Light Workshops

David Palumbo and Independent Power & Light of Hyde Park, VT will hold several intensive one-day workshops in the spring & summer of 1991. The workshops will include solar, micro-hydro and wind selection, battery choices - NICAD vs. lead acid, charge controls, inverters, protection devices, wiring, and estimating loads for system design. Tours of state-of-the art systems will be made.

The workshop will be on April 20, May 25, June 20, and July 27, 1991. They will run from 8 A.M. to 5 P.M. Cost for each workshop will be $95.00 which will include "The Solar Electric Home Book" by Paul J. Fowler, "The New Solar Electric Home" by Joel Davidson and a three ring binder full of product descriptions, reviews and catalogs. Lunch is included. The books will be mailed on receipt of each registration. Participants will be expected to read the books prior to the workshop. A deposit of $35.00 is required for registration as workshop size is limited. For more information contact: Independent Power & Light, David Palumbo or Kathleen DeCalle, RR1 Box 3054, Hyde Park, VT 05655, or call 802-888-7194.

Hands-On Workshops in Maine

The Maine Solar Energy Association has started a series of hands-on solar workshops all around the state of Maine. The purpose of these practical, one day events is to de-mystify solar energy by showing the participants that it is practical today to use the sun to heat your home, make your hot water, furnish your electricity, and even cook your food and grow your vegetables out of season. In the past year we have had a very successful passive solar architecture workshop in Bangor, a solar greenhouse & sunspace workshop in Falmouth, and two photovoltaics workshops. The participants of the PV workshops actually constructed solar cell modules that they could take home for the cost of the parts. The fee for each of these workshops is $25.00, which includes lunch. For information on sites and dates contact Richard Komp, Maine Solar Energy Association, RFD Box 751, Addison, ME 04606, 207•497-2204

NE Sustainable Energy Assoc.

March 1-3, 1991 - 8th annual QUALITY BUILDING CONFERENCE, sponsored by the Quality Building Council of the NESEA, Springfield, MA. Contact: NESEA • 413-774-6051

May 21-25, 1991 - 3rd annual AMERICAN TOUR de SOL, The solar & electric vehicle championship, sponsored by NESEA, Albany, NY to Boston, MA. Contact: NESEA • 413-774-6051

May 24-26. 1991 - ENERGY AND ENVIRONMENTAL FAIR, Plymouth, MA. Contact Earth Rising Productions • 617-489-4890

October 25 & 26, 1991 - SOLAR AND ELECTRIC VEHICLE SYMPOSIUM, Sheraton Hotel, Boxborough, MA JUST OFF RT 495. CONTACT NESEA, 413-774-6051

Minnesota Energy Council

The MN Energy Council will hold a number of conferences on new technology in energy and environmental management for housing, small buildings, small business and municipal buildings, aimed at professionals and business people. For more information contact: Roger Peterson, Minnesota Energy Council, Box 8222, St. Paul, MN 55108 • 612-378-2973

Solar World Congress

The Solar World Congress of the International Solar Energy Society will be held on August 17-24, 1991 in Denver, CO. Contact: American Solar Energy Society, 2400 Central Ave. Ste. B-1, Boulder, CO 80301 USA, 303-443-3130, FAX 303-443-3212.

SunAmp Seminar

SunAmp Power Co. will hold two, 2 day PV seminars on March 15 & 16 & May 17 & 18, 1991. The seminars are designed for everyone from professionals to do-it-your-selfers. Topics will include introduction to PV hardware, demonstrations of systems, instrumentation, information access, system design and marketing. Cost of each seminar is $145.00 ($100. for each additional person in the same party) and includes two lunches, refreshments, syllabus & classroom materials. For more information contact Steve at SunAmp Power Co., POB 6346, Scottsdale, AZ 85261-6346 • 602-951-0699 or TOLL FREE 1-800-MR SOLAR.

Free Hydro Software

Peltech is offering free IBM PC compatible software called "Hydrohelper". For more info contact William Kitching, Small Hydroelectic Systems & Equipment, 5141 Wickersham, Acme, WA 98220, 206-671-4326.

Photron Technical Training Seminar

Photron, Inc. will be holding a two day Technical Training Seminar on March 23 & 24, 1991 in Willits, A. Seating is limited, the registration fee is $50. US/$60. Can. and includes continental breakfast & banquet luncheon on both days. To register contact Photron, Inc., 77 W Commercial St, Willits, CA 95490, 707-459-3211 or in Canada POB 136, Colinton, Alberta, Canada T0G 0R0, 403-675-2586.

The Midwest Renewable Energy Assoc.

The Midwest Renewable Energy Fair Association (MREA) is a non-profit organization whose purpose is to promote renewable energy and energy conservation. MREA, a grassroots organization was founded by a group of individuals with a commitment to preserving and improving the quality of our environment. The MREA relies almost entirely on the efforts of volunteers.

MREA's first Energy Fair held in August 1990 was a great success. It attracted 4,000 people from 18 states and 2 foreign countries. Display and product booths, demonstrations, educational hands-on workshops, speakers and entertainment highlighted the event.

The 1991 Energy Fair (June 21-23 in Amherst, Wisconsin) will be bigger and better. Look for new workshops, upgraded facilities, a high efficiency renewable energy model home, and increased attention to alternative transportation methods.

Although the Energy Fair is our major event, we are expanding our commitment to providing energy education throughout the year. MREA has just received two grants. One from the Wisconsin Energy Bureau's "oil overcharge fund" for $40,000 and one from the Wisconsin Environmental Education Grant for $16,543.

MREA is inviting folks to become members. The $25.00 membership fee would intitle you to membership, free admission to the 1991 Energy Fair, MREA's quarterly newsletter, discounts on MREA videos & audio cassettes, free classified ads in the newsletter, one vote at the general membership meeting and a free 1991 Energy Fair T-shirt.

For more information on the 1991 Energy Fair, presenting workshops, booth information or memberships contact: MREA, Box 249, 116 Cross St., Amherst, WI 54406, 715-824-5166.

The Big Island Alternative Energy Fair

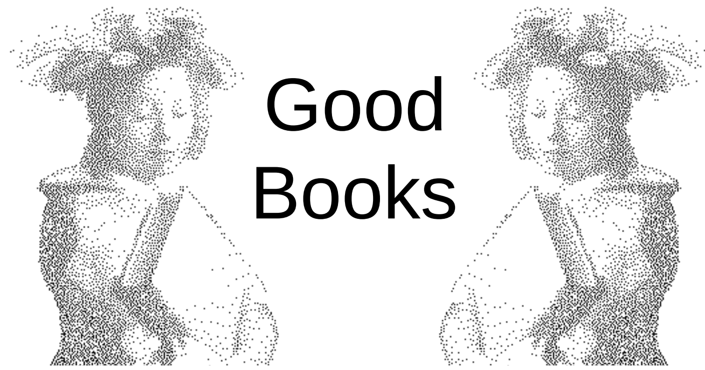
The Big Island Rainforest Action Group, as part of its campaign to stop geothermal development in Hawaii, is sponsoring an alternative energy fair and concert to be held on the Big Island of Hawaii on June 28 & 29 1991. "Our group has taken an unconditional stand against geothermal here in the islands", says Kristine Kubat, spokesperson for the group. "That puts us in a difficult position because the State is promoting the use of geothermal as a means for achieving energy self-sufficiency. We're in favor of self-sufficiency in the broader sense, the extent to which we as individuals can reach out there and grab our own power. Geothermal development not only endangers our forests and jeopardizes the health of those living near proposed developments, it undermines the efforts of those working towards true energy independence. I guess it's up to us to validate the options." The options in this case include a system that will power both the fair and the concert by making use of Hawaii's sun and tradewinds, mass transportation to and from the site (an as yet undetermined, unspoiled corner of Paradise), the recycling of all wastes generated by the event, and the use of solar cookers to prepare the food. "We're hoping to design a light show for the concert that would be powered by bicycle generators. People can get up there and create effects by pedaling to the music. It'll be fun." adds Kubat. Russell Ruderman, in charge of the system that will power the event admits he's faced a challenge. "We're getting a lot of support from many of talented people. We're open to suggestions as well as technical assistance from anyone interested." Asked if he believes the group can pull it off Ruderman answers, "Absolutely, there's too much at stake here, for us and for everyone who believes in a sustainable future". If you'd like to be part of the effort, or you're interested in a booth, contact the group by writing to Kristine Kubat at SR 13062, Keaau, HI 96749 or call her at 808-965-7471.

Southwest Regional Energy Fair

This fair will be held in Bernalillo, NM. This fair will encompass all forms of energy indigenous to the southwest region. Workshops, seminars, open forums and historical and commercial exhibits will focus on energy conservation, building materials and equipment common to the Southwest. For information on attending, becoming an exhibitor or a sponsor:S.R.E.F. c/o SEMCO, 901 21st St. NW, Albuquerque, NM 87104 or call 505-247-4522.

Symposium in Bellevue, Washington

On June 8, 1991, Bellevue Community College (10 miles east of Seattle, WA) will host the Alternative Energy Symposium and Fair. The thrust of the symposium will be educational workshops. For more information contact, Olof Sundin, J121 Bellevue Community College, Bellevue, WA 98007-6484, 206-641-2263, Fax 206-453-3032



World Wildlife Fund Atlas Of The Environment

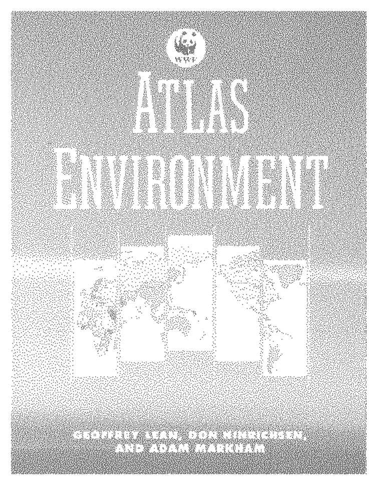
by Geoffrey Lean, Don Hinrichsen, and Adam Markham

Reviewed by Stan Krute

This information-filled book contains beautiful maps, charts, and diagrams that graphically document many aspects of our planet's health.

There are 42 well-focused chapters. Each one includes several maps and diagrams and an excellent overview essay. To give you an idea of the book's breadth, here are some of the chapter titles: Drinking Water and Sanitation, the World's Fisheries, Health, Industrialization and Development, Renewable Energy Resources, the Greenhouse Effect, Biological Diversity and Genetic Resources, and Wildlife Trade.

The illustrations are the heart of the book. They are quite wonderfully done, presenting large amounts of sophisticated information in a direct, accessible manner. There are over 200 of them. Here are some of the titles: Existing Deserts, Refugee Populations, World Distribution of Temperate Forests, Infant Mortality, Ozone Concentration in the Atmosphere, Major Bird Migration Routes, Effects of Climate Change, Per Capita GNP, and Deep-Sea Dump Sites.



This book will be especially useful in a classroom. Beyond its obvious utility as a source of information about the natural and human environments, the book contains material that can trigger learning in many subject areas: history, geography, forestry, oceanography, economics, biology, sociology, mathematics, cartogrophy, and more. It's also an excellent sourcebook for teaching students how to understand and analyze graphically-presented information.

The book was produced in Great Britain. Its production qualities are excellent. The illustrations are colorful, clear, and intelligently organized. The authors and cartographers have used a wide variety of sources to assemble the most authoritative available data.

If you're interested in the status of your planet, and want information in an accessible format free of polemic, this is the book to have. I hope it is revised and republished often.

The book is published by Prentice Hall Press, 15 Columbus Circle, New York, NY 10023. The hardcover version (ISBN# 0-13-050469-6) costs $29.95, the paperback (0-13-50436-X) is $21.95.

ECOLOGUE

Edited by Bruce N. Anderson

Reviewed by Kathleen Jarschke-Schultze

Most catalogs are wish books. The Ecologue is a wish book, but it is so much more than just that. The cover says it is the Environmental Catalogue and Consumer's Guide for a Safe Earth. I found it to be educational in many areas of environmental concerns.

Each chapter starts off with information about the type of product and the concerns in that environmental arena. Highlighted boxes throughout the book, called 'What You Can Do' give you actual methods for being more ecologically tuned in to the earth. Short snippets of even more facts are printed at the bottom of each page. I, for one, will really try to not drink out of styrofoam cups anymore. I just don't want that styrene building up in my fatty tissues.

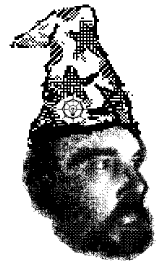
I really like catalogs with pictures and a little text on each product. This fills that need. By not selling the products themselves they are able to list many different products and their access info. I really wasn't aware of the many different choices of safe products in so many different areas.

In his introduction, editor Bruce Anderson, explains how they obtained their information on the products, the testing and criteria for getting a product into the catalog. What impressed me was that he admits that although they did their best to be correct they did make some mistakes. He also includes two postpaid postcards to send in your comments and earn yourself two editions of the Ecologue/Update free. Bruce asks for input repeatedly. He wants to gather all the info and access he can. I salute his fine effort.

For those people who have trouble wording letters of complaint to companies who do not practice safe environmental standards or packaging Bruce provides a sample letter. Later, at the back of the book he provides a comprehensive Ecologue Source Directory.

I enjoyed this book. It was hard to put down, even though I wasn't really shopping for anything in particular.

Available from International Environment Group, Inc., Box 71NA, 71 Sargent Camp Road, Peterborough, NH 03458 for $18.95. The ISBN # of this book is 0-13-084518-3.



The Wizard Speaks…

What's important and what's not…

The key to the conservation of energy and resources lies in awakening the understanding of what is important and what is not. When this happens, conservation naturally follows. Let us look at what is important and what is not.

Quality of life is important, quantity is not. Necessary consumption is important, conspicuous consumption is not. The development of feeling and awareness is important, the accumulation of material objects is not. Knowledge and understanding is important, dogma and fanaticism are not.

This does not mean that anyone should suffer from the lack of needed essentials. On the contrary, all should, in fact must, have what they need to be comfortable. The above understandings can lead to the knowledge of true need. Between the limits of too little is not enough and too much is enough, can be found the key to living in harmony with the environment while satisfying personal needs.

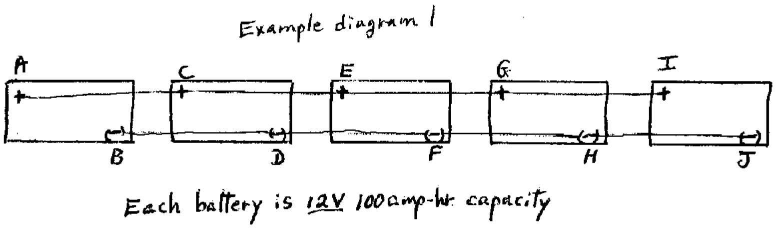
The arising of this realization leads immediately to an easy and painless conservation ethic that is real and lasting. In simple terms, it may be expressed as "do what you can, and try not to use more than you need". It works for me!

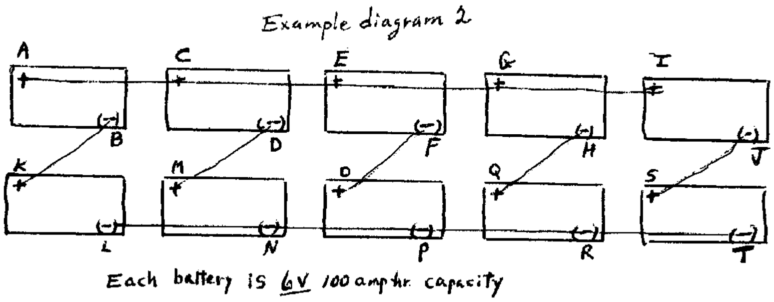
Letters to Home Power

We Print 'em Unedited.
Selected & Entered by
Kathleen Jarschke-Schultze

WIRING DILEMMA

Dear Richard, In an attempt to clear up (settle) a long standing disagreement over the proper way to wire into (input) and out of (output) banks of batteries, would you clearly (specify) where 12VDC cables should be connected for each diagrammed example below?





From the large numbers of people I encounter each year, too many don't know the correct connection points. I believe it important enough that this be shown to your readers.

In each example, the input charge is at 12 volts, as well as output to service circuit(s). For diagram #1: Should 12VDC Input (charging) source be connected to- A&B?, E&F?, A&J?, or ? Where should Output cables be connected? Similarly for diagram 2: Should 12VDC charging (input) cables be connected at- A&L?, B&K?, F&O?, A&T? or ? Where should cables be connected for output? I have purposely left out fuse boxes, circuit breakers, switches, meters, etc., to simplify the diagrams.

Lane Honn Sr, POB 312, Blanca CO 81123

In example diagram 1, connect to points A & J. In example diagram 2, connect to points A & T. These are connection points for the input/output cables feeding the main DC buss connection. All inputs and outputs are connected to the buss and not directly to the battery. This keeps corrosion down to a dull roar by reducing the number of mechanical connection made directly to the battery. The reason to connect at these points is to equalize the current loading on all cells within the battery. At high currents, like those demanded by inverters, even miniscule amounts of resistance can unbalance the current flows with the battery. Using the points mentioned above gives all the cells within the battery equal resistance access to all current flow. It's a matter of symmetry. RP

DPTA?

Dear Richard and Karen, We enjoy HP very much. The information exchange, sharing and cross pollination is of great value. The readers and authors of HP demonstrate refreshing individuality and accomplishment. Alternative approaches to energy and living are often considered not practical or not do-able. It is nice to see the not do-able yield nicely to non-lemming thought and effort.

We would like to be on the OOZIE list. Very interested! Carolee liked the solar cooker info and recipes. More articles from a ladies view, about AE living and doing, would be helpful.

The article on EDTA in sulphated batteries was interesting! I discussed the article with a chemist friend. He offered a few thoughts:

1-DPTA should also be investigated for this use.
2-DPTA is more soluble in a strong acid solution then EDTA.
3-Trying DTPA in the original electrolyte might allow recovery of lead lost from the plates to the sulphate compounds.
4-DTPA might be used in the electrolyte, on an ongoing basis, to retard or prevent sulphation.

Jim & Carolee Miller, POB 537, Ontario, OR 97914

Thanks for the flowers, Jim. Kathleen wrote a "ladies view" article for this issue, see page 40. EDTA is only one of a family of chelating agents that may prove useful for rejuvenating sulphated lead-acid cells. We mentioned EDTA because we've tried it and it works. We welcome info from anyone who has successfully used other chelating agents. RP

OOPS!

In HP#20 under the letter titled Northwest Net I inadvertently misspelled Richard's surname. Here then is the correct name and address: Richard Salitra, 780 Front St South, Apt 310, Issaquah, WA 98027, (206) 391-3606. *KJS*

COLD LOGIC

Dear Richard, Sure wish your battery book was still available. It might answer my question about resetting the high and low voltage disconnect/reconnect of my Trace C-30-A.

The voltage controller is factory set for "temperate" climates, with High Voltage disconnect at 14.7 v and Low Voltage reconnect at 13.2 V.

What happens at this location is many idle periods on sunny days even though the battery bank is far from fully charged. After re-reading your article in HP #9, p. 27, I concluded putting my batteries in an old chest freezer was a mistake. They're too cold, averaging about 10 degrees above the ambient air temperature. My December monthly mean temperature was 44 degrees; the extremes were 11 and 72 degrees. Now I've added a 15-watt 12V bulb in the battery box and it seems to keep the temperature about 20 degrees higher than outside. I may also add more insulation (rigid).

My belief is that without warm batteries they won't accept much of a charge, hence driving up the voltage and turning off the panels. (I can easily see this on the meters of my AEE DC Load Center). Would raising the low-voltage reconnect be good? How much? My battery to panel ratio is C/33. (Six Trojan T-105's with Hydrocaps fed by 7 panels totalling 20 A.).

May I add my vote of confidence for your recent decisions on the future of Home Power and your candid rationale in HP #20. Enclosed is $20 to extend my subscription and upgrade to 1st Class! If you're curious about "Tuoliposa" it's because the

Mariposa-Tuolumne county line runs right through my home known as "Tin Shack". Here's to more energy independence!

Sincerely, Chuck Heath, Box 1159, Coulterville, CA 95311

Hello, Chuck. You bet, raise the low-voltage reconnect to between 13.8 and 14.2 VDC. With the ratio of panels to battery capacity that you have, there is little danger of overcharging by upping the low-voltage reconnect point. Lead-acid cells are very sensitive to cold. If they are below 45° F., then their voltage excursions under charge and discharge are both increased. Also their effective capacity and efficiency is reduced. So keep 'em warm in the winter. RP

STEVE WILLEY ANSWERS

Good Chip Usal, You wrote of having trouble with a Technics turntable on Trace inverter power. I am surprised, and wonder if the noise is electrical noise producing sounds in the speakers with the music, or if it is physical noise from the turntable transformer and mechanism directly?

Back before there were small low cost efficient inverters, we used to convert Technics turntables to operate directly from 12 volt DC power. We did this to save power and make economical turntables available to folks without inverters. Some models were very easy, some less so. The models we used were mostly from late 70s and the 80s, belt drive and DC motor. Direct drive models required 24 volts and were not used. The key to using DC directly is that the motor and circuits in most models operate on 12 volts all the time. The AC you plug into the turntable is converted to 12 volt DC FIRST THING in the turntable circuits, for everything except the strobe light which visually confirms the speed adjustment. The AC power does go through a switch first, so we had to rewire the switch out of the AC circuit and into the DC portion. Technics brand changes models very often, so there is no consistent set of instructions for do-it-yourself, but knowing it is possible, now perhaps you can get local help as may be required to make this conversion, if necessary.

Is that really necessary? The reason I wondered about the nature of the noise is that we tested these turntables both ways, AC and DC power before selling them, and I don't remember having any noise problem with them either way. If the noise is through the speakers, and not mechanical, be sure your audio cables are grounded and the chassis ground terminals on the turntable and your amplifier are wired together. Also be sure the AC power cords lay as far from the audio cables as you can get them.

Steve Willey, Backwoods Solar Electric Systems, 8530 Rapid Lightning Creek Road, Sandpoint, ID 83864

Motors and Generators

Dear Friends, I feel compelled to comment on Mick Sagrillo's article on rewinding generators/alternators (HP 19). I have 23 years of continuous experience rewinding and repairing electric motors and generators, both A.C. and D.C., from fractional to over 1000 HP in size. I believe that the author has mislead our readers on a number of points regarding redesign practices. My experiences support the following:

1. There is no difference between a motor and a generator. Both machines are electro-dynamic energy converters, commonly known as the DYNAMO. The terms motor, generator, and alternator denote a more specific application or type of dynamo.

2. Redesign by rewinding often only changes one design parameter, such as the voltage, speed, or horsepower rating. A direct current dynamo is a constant torque machine, with speed directly proportional to the armature voltage. (This is true for machines with a fixed field, such as a wound shunt field or permanent magnet field. It does not apply to machines with a series field winding.) Often, we are able to utilize a dynamo with one particular rating on a system with different requirements, without rewinding. EXAMPLE: We have on hand a D.C. dynamo with a nameplate rating of: 1 HP, 1800 RPM, 120 Volts (armature), 7.5 Amperes (armature), permanent magnet field. What rating should we expect on an application with a 12 volt system? The speed will be : (12 Volts / 120 Volts) X 1800 RPM = 180 RPM. The horsepower rating will be: (180 RPM / 1800 RPM) X 1 HP = 1/10 HP. Note that this dynamo will not be cooled as effectively at the slower speed, so the HP rating should be reduced to compensate, or add a blower (forced cooling), or operate intermittently. The full load armature current remains at 7.5 A, subject to derating for cooling purposes if necessary. We now have a slow speed dynamo without rewinding.

3. The number of poles in a D.C. machine has nothing to do with the operating speed. The operating speed of a D.C. motor varies directly with the armature voltage. Conversely, the voltage of a D.C. generator varies directly with speed. Slow speed, low voltage machines often have a greater number of poles than do higher speed machines. The Jacobs wind generator utilizes a six pole design, while the Wincharger machines were two pole designs. Ordinarily, it would not be possible to change the number of poles in a D.C. dynamo. A pole change to a greater number of poles would require an armature coil pitch change, commutator lead pitch change, extensive fabrication and modification to the field frame and pole pieces, adjustment in the brush spacing around the periphery of the commutator, and in the case of an armature with a lap type connection - additional brushes and holders (1 brush per pole required). In addition, flux density calculations and other winding data would be necessary. I would not attempt a redesign of this type.

4. I disagree with the idea that "field strength can be increased by decreasing the number of turns in the individual coils". Here is why: Most D.C. shunt fields operate near the maximum thermal limit of the insulation system. The source of heat is the I^2R Watt losses of the field coils. The current carrying capability (within reasonable temperature limits) simply does not exist for an increase in field current.

Consider a recent motor in for repairs: Westinghouse 1 HP, 2200 RPM, 115 Volt field, two pole, 2140 turns per pole, one of .0226 inch diameter Cu wire, coil weight 1850 grams each. Measured resistance of field: 106 Ohm; Field current: 1.08 Ampere (cold). If we reduce the turns by 10%, the total field resistance will decrease by more than 10%, because the turns removed from the outer periphery of the coil will be of greater length than the mean (average) turn. But let us figure on only 10% reduction in resistance with the 10% turns reduction and see what happens:

106 Ohm X .9 = 95.4 Ohm (the new field winding resistance)

115 Volts = field excitation voltage

I = E/R = 115 Volts / 95.4 Ohm = 1.2 Ampere (the new field current)

Watt loss = I^2R = 1.08 Ampere X 1.08 Ampere X 106 Ohm = 123.6 Watts (original field loss)

Watt loss = I^2R = 1.2 Ampere X 1.2 Ampere X 95.4 Ohm = 137.4 Watts (new field loss), an increase in losses of 13.8 Watts, or 11.2% increase in losses.

What about our field strength? The field strength is determined in part by the magnetizing force H, or ampere-turns (NI). Original winding NI = 2140 turns/pole X 1.08 Ampere = 2311 Ampere-turns/pole. New winding NI = (2140 X .9) turns/pole X 1.2 Ampere = 2311 Ampere-turns/pole. The field strength has not

been changed at all! However, our motor now runs hotter, has shorter life, and is less efficient.

Now, let's figure the results when a practical value of field resistance change is considered (15%), with the 10% turns reduction:

106 Ohm X .85 = 90.1 Ohm field resistance

E = 115 Volts = field excitation voltage

I = E/R = 115 Volts / 90.1 Ohm = 1.27 Ampere field current

Watt loss = I2 R = 1.27 Ampere X 1.27 Ampere X 90.1 Ohm = 146.8 Watts of field loss, an increase (from the original winding) of 23.2 Watts, or 18.8% increase in energy losses.

NI = (2140 X .9) turns/pole X 1.27 Ampere = 2446 Ampere-turns/pole, an increase in magnetizing force of 135 Ampere-turns/pole, which is only an increase of 5.8% in magnetizing force. THIS IS NOT AN INCREASE IN FIELD STRENGTH OF 5.8%. The field strength does not vary linearly with the magnetizing force. A B-H curve (called a characteristic curve or saturation curve) for this particular machine would have to be available in order to determine the actual effect of the change in magnetizing force. This small increase in magnetizing force will produce a slight increase in field strength, however we now have nearly 20% greater field losses.

5. Paralleling a winding by reconnecting the individual coils is a simple way to reduce the operating voltage. Changing from a series connection (1 circuit) to a two parallel connection (2 circuits) will change the voltage rating by the ratio 1/2, or 50% with the same field strength and losses. This is quite common in dual voltage rated windings. A sample name-plate might read: Field voltage: 150/300; Field current: 2.48/1.24, typical values for a modern 20 HP, 1750 RPM base speed direct current motor. If we were to apply the higher value voltage to the parallel connected fields, we would observe an increase in field current above normal of 200%, and an increase in field losses of 400%, and extremely short winding life. This would be equivalent to attempting to operate a 120 Volt lightbulb on a 240 Volt supply.

6. Indeed, an air gap is necessary in rotating electrical machines. While the air gap does add a series reluctance in the magnetic circuit, air gaps are not "excessive", and especially not excessive due to "sloppy construction". I bet that the tolerances of electrical machines are quite good. One reason that the air gap is greater than what might be hoped for is due to shaft deflections of the armature (or rotor) reducing the air gap (clearance between the rotor and stator). Rotor magnetic pull-over forces during starting or plug reversing are substantial, due to the tremendous increase in current during the acceleration interval. Typical values of inrush current are from 600% to 1000% of full load current, when full voltage is applied. (This is for induction motors.)

7. ON WIRE: Think in terms of circular mils per ampere. Typical values are 500 CM/A to a low of 250 CM/A, depending upon application, cooling and duty cycle. The lower values of CM/A have higher current densities, and higher Watt losses. Higher densities require greater cooling efforts (such as cooling fans), hence even lower efficiencies.

8. An interpole winding is often required in D.C. equipment to aid in commutation. Sparkless commutation will promote extended brush and commutator life. The interpole winding (or comm coil) is in series with the armature and is designed with large wire to carry the armature current. Removal of the interpole winding probably will result in the brushes sparking under load. A typical interpole coil might be approximately 1/3 of the physical width of a main field coil. A main field winding coil will not physically fit in a space vacated by an interpole winding coil. The Jacobs wind generator utilizes a straight shunt field winding without interpoles. Some models of Wincharger generators use shunt fields, series fields, and interpole fields.

9. The 5.5 series 1D Delcotron automotive alternator is a 14 pole, three phase synchronous alternator with a rotating field and stationary armature winding (stator). The stator lamination stack height is .750 inch, with each lamination having a thickness of approximately .045 inch. The stator laminations are punched for 42 slots. The stator winding consists of 21 coils, there being 7 coils per phase, continuously wound by machine from one coil to the next coil, eliminating the series connection splice between pole-phase coils. The starting ends of each of the three phases are connected together at a common point called a WYE or STAR point. This is known as a single circuit wye (or star), consequent pole connection scheme. The coil pitch is from slot 1 to slot 4, spanning 3 stator teeth. Each coil is wound with 9 turns/coil, 1 of .0508 inch diameter Cu film coated magnet wire. The rotor assembly consists of a single field coil, situated between two finger plates; each plate having 7 fingers, all mounted on a common shaft along with a pair of slip ring collectors. This rotor design is known as the Lundel type of rotor. Automotive alternators are designed to operate over a wide range of speeds, from 2,000 RPM to over 7,000 RPM. The frequency of the induced voltage in the stator windings varies with the operating speed, between 200 HZ and 800 HZ. The Chrysler alternators mentioned in the article are probably similar in construction and design. If we strip two core stacks and mate them together, we now have a stator with twice the effective inductor length of the original stator. If the air gap flux density (lines per square inch) is held to the same value across the entire length of the new stator, as the original stator had, we could expect a reduction in rotor speed by 50% to obtain the original output voltage. Conversely, this is the same effect as doubling the output voltage at the SAME rotor speed as before.

A plot of the magnetic lines of flux representing a typical distribution pattern for rotors of the Lundel type will show a concentration of flux lines near the center of the two rotor halves. The flux density decreases to near zero at the ends of the rotor fingers. Inserting this rotor into a lamination stack of twice the original length will not significantly change the flux distribution pattern. The lines of flux will spread out, due to lower reluctance paths, but the average flux will not be twice the original value, as was hoped for. Consequently, the output voltage change will not be as great as had been anticipated.

Automotive alternators are not models of efficiency. The magnetic hysteresis and eddy current losses are much higher than for industrial or domestic motors. Steinmetz demonstrated that the hysteresis and eddy current core losses increase as frequency increases, and that eddy current losses increase dramatically when thicker laminations are used. Sixty Hertz machines typically have laminations of .015 inch thickness. This is 1/3 the thickness of automotive alternator stator laminations. Automotive alternators are designed for economy in manufacturing, tooling, and materials costs - not for high efficiency.

10. My book list would include any first year electrical engineering text for basic, fundamental theory of electrical and magnetic principles. A good example is Introductory Electrical Engineering by professors George F. Corcoran, M.S. and Henry R. Reed, Ph.D.; published by John Wiley & Sons, New York (copyright 1957). I also recommend the book Electric Motor Repair Shop Problems and Solutions, by Samuel Heller, P.E.; published by Datarule Publishing Co, Inc., P.O. Box 448, New Cannan, CT 06840. This book presents redesign solutions without involving the

reader in heavy mathematics - it was written for the practical motor repairman.

I appreciate the fact that professionals in a given field of technology often have different perspectives and opinions on certain topics. Perhaps a third party professional could critique and review future technical articles, especially articles concerning topics outside of the editorial staff's experiences. I welcome Mr. Sagrillo's rebuttal.

Richard W. Walter, KE5MI, 3415 Roosevelt Drive, Dalworthington Gardens, TX 76016

Mick Sagrillo answers Richard Walter

Thanks for allowing me the opportunity to respond to your letter concerning my article on rewinding. While I respect your experience and opinions, I have to disagree with many of your conclusions because, I believe, you view this process from a different perspective, that of a motor rewinder. While some principles apply to rewinding both motors and generators, their application to slow-speed wind generators allows much fudging.

By the way, I am not smart enough to have made any of this up. Everything in the original article has been taken from various texts on electromagnetic dynamo design principles, including one of the two you mentioned in #10. It also comes from trial and error in finding out what works and what doesn't. Call it applied theory, and we all know that theory doesn't always translate out into reality. I in no way intended to mislead readers, nor do I believe the article does that. Here goes, point by point.

1. There is a major difference in both the design and function of motors, generators, and alternators. They are not interchangeable, and can only be made so in special cases. The two exceptions are DC motors and generators and some induction motors/generators (and this is not always true). The major differences between motors and slow-speed wind generators is that motors operate under constant voltage, more or less constant current and constant load, have extremely high start-up torques, and are fairly closely matched to an optimum load. Cooling becomes very important to the life and continued operation of the motor as it is usually best run near its peak capacity. Slow-speed wind generators, on the other hand, have no start-up torque, operate under continually changing voltage and current, have wildly variable loads, and rarely reach their peak capacity. Because they rarely reach peak capacity, cooling is of little concern. When they do reach peak, it's because the wind is blowing like hell, so cooling is no problem. I mention this because you are quite concerned about cooling further on in your letter. Motors and wind generators operate in vastly different environments.

2. I agree that rewinding usually changes only one parameter. In fact, to keep things simple, we should strive to change only one parameter at a time. I disagree with the second part of this response. While running a DC dynamo at slower speed will result in lower voltage, it also results in reduced current. (If you did this with a motor, it would quickly overheat.) More importantly, you need to design the generator to reach its peak voltage at its peak rpm. Otherwise, any over-speed situation will result in a potentially catastrophic high voltages. Many home brewed wind systems, control panels and battery banks have been destroyed by this very mistake. Again, note that cooling would be of no concern.

3. I didn't make this up. This is basic electromotive dynamo theory. As a matter of fact, you contradict yourself a little later by stating that "slow speed, low voltage machines often have a greater number of poles than do higher speed machines". I believe that this was my point. And while it is true that Jacobs have six poles while most Windchargers have only two, you failed to mention that Windcharger generators, both the small direct-drive units as well as the gear driven models, run at much higher speeds than the Jakes. This reinforces my point.

4. Increasing field strength by decreasing coil turns is not my idea, but another fundamental electromotive dynamo design theory. My oldest reference for this "idea" dates back to 1896. However, I agree that because of cooling problems, you couldn't do this very successfully with a motor. But again, we're talking slow-speed generators, not motors.

5. I agree with you that paralleling coil windings will cut voltage roughly in half. Or at the same voltage, it will cut the rpm in half. Paralleling coils has the same effect as cutting the number of coil windings in half, which you disagreed with in #4. Make up your mind!

6. Large air gaps are extremely important in motors where the instantaneous application of full voltage and current can cause tremendous distortions and flexing of the main shaft. However, as I stated earlier, there is no inrush of voltage or current on a slow-speed wind generator and no start-up torque. Motor principles don't apply here. We're talking apples and earthworms (not even as close as oranges).

7. Cooling and duty cycle does not apply to wind generators as it does with motors. Motor duty cycle is designed to approach 100%. A good wind generator will have a duty cycle (we call it capacity factor) of 15%.

8. I agree.

9. I believe your conclusion about stacking laminations is the same one that I stated in the article.

10. Motor rewinding problems have little applicability to slow-speed wind generators. They are very different animals!

Let me conclude by saying that I believe that you missed the point of my article. Your experience stems from motors and motor rewinding, mine from slow-speed wind generators, some theory, some trial and error. It seems to me that we're talking at right angles and in different planes to each other.

Mick Sagrillo, Lake Michigan Wind & Sun, RT1 Box 149, Forestville, WI 54213, 414-837-2267

WOOD FUEL

Dear Home Power, I feel a need to respond to Mick Sagrillo's letter regarding "Appropriate Technology", or better yet, "Appropriate Fuels". I live on the opposite side of Lake Michigan from Mick, and in the winter, lake effect clouds make 10-20 day sunless stretches common. PVs supply most of our electricity, but in these dry periods I dream of a way to generate my electricity from the wood I burn.

What I want to point out is that wood can be, if prudently and conscientiously used, a guilt-free fuel. Forests are the only carbon sink we have going for us, and it is possible to strike a balance, where your woodlot locks in as much carbon as you release from burning.

Everyone's heard that 5 acres of trees, properly managed, is an inexhaustible supply of heat for the average home. I think this is overly optimistic, but the theory is correct, you can grow your fuel using natural solar collectors the same as you can grow your food.

But you must be an informed woodlot manager, able to identify stagnant growth, diseased trees, and willing to utilize "undesirable" fuelwoods. Decaying wood releases the same amount of carbon as burning it, and a tree traps carbon the fastest in its first 20-40 years.

Burn your wood, don't smolder it. Airtight stoves are wonderful for making a fire last, but are horrible for emissions. Now that catalytic combustors are easily available, they should be a must for all wood burners. Producer gas generators are very enticing, but I'd really

like to know more about their emissions.

I have an example of an "appropriate fuel" that could make an interesting discussion. In the 60's our area was explored (exploited) for oil and gas. Several gas wells weren't large enough for commercial development so the landowners opted to pipe the gas to their homes, and have enjoyed 30 years of free natural gas. One could argue that this would be similar to having geothermal, or excellent hydro, though some would say the emissions and source negate any benefits. But if it was in your yard, would you cap it off?

Also, I have a question. Does anyone know of low voltage, or highly efficient, vaporizers or humidifiers? Some option besides pans of water on top of the wood stove to combat dry winter air and clogged kids.

Thanks, Ray Bell-Dereske, R1 Box 660, Branch, MI 49402

As to interest in gas producers please read article in this issue. We have not been able to find a low voltage or highly efficient vaporizer or humidifier, Ray, although there are some stove top ones that are shaped like dragons and whales if you want to pay the price for style. KJS

TWO LIGHT OR 12V

Dear Home Power, I enjoyed your informative series on efficient AC lighting in Home Power #20, but the articles didn't address a question that seems basic to the concept of running AC lights on an inverter.

The question is - when burning only one or two lights at a time, is it more efficient to employ DC lights and leave the inverter on standby (or turned off), or is the AC/inverter combination more efficient even at these very small loads?

I have some auto tail light adapter 12 volt DC lights I have used for years, and I am wondering if I should switch to AC lights from my new Trace 2012. I'll bet a lot of readers are asking similar questions. Thanks for a great magazine.

Sincerely, Doug Ferrell, Trout Creek MT

The answer depends on several things. The type of inverter you're using and the type of 12V light that the compact fluorescents are replacing being the main variables. Given that your inverter is one of the newer types (as opposed to an old Tripplite or somesuch) and that the 12V lights being replaced are incandescent, the answer is yes, the inverter/compact fluorescent combo is more efficient. If the lights being replaced are 12V fluorescents, the equation becomes much less clear-cut and factors like the better longevity of the 120vac lights and reduced RFI noise levels have to be figured in. In your case, using the Trace 2012 to run two 11 or 15W compacts will be much more efficient than running two 12V tail lights. The fact that you'll also get two or three times more lumens out of the deal is icing on the cake. Bob-O

TUNDRA VIEW

Hi Wiz, I too live in an out of the way place by myself with a couple of "renewable energy powered security systems". My nearly 70 year old hearing not being as keen as it once was, I appreciate them for that purpose, but also for packing and sled pulling.

From where I live it's 70 miles to the nearest road, 30 air miles or 45 mi. across nearly impassable tundra country to the nearest P.O. So I only get mail every two or three months & often less often.

I like plenty of elbow room but also appreciate having a young family not far away who are good neighbors. I like the challenge of doing as much as I can for myself with what is locally available. Younger neighbors thought I was a wizard when it came to that, but I'm not, just a lot of experience and curiosity. Life on earth is a learning experience all the way.

Sure appreciate it when I hear of people who realize there are others who need a fair shake of the planet's resources now and in the future. Besides, the more a person can do for oneself the less we are just an extension of someone else's ingenuity and initiative and the more we are individuals in our own right.

Near as I can figure out we are on this planet to learn the appreciations that make life worthwhile and perhaps become people who are willing and trying to live as good neighbors who can be trusted to be part of a permanent society of friendly people in which everyone will have access to satisfying experiences, after we graduate from here. The pains of this life are educational. They load our memory with appreciations so they won't be needed in the next life and if we don't get stubborn and flunk out we can then live life free from all the unpleasantness we now know. Seems to me your "Home Power" magazine reflects some of these values too. Won't be too long before I'll be "graduating" then I'll know more about it. (I've written a small book about such things that most Christians don't like, but philosophers do).

I can say with Robert Service, "I have clinched and closed with the named North. I've learned to defy and defend shoulder to shoulder we have fought it out- yet the wild must win in the end." This is true but the "North" has shown it's friendly side also, and with John Ruskin I've come to realize, "The highest reward for man's toil is not what he gets for it but what he becomes from doing it." It is a good thing because for various reasons I don't have much to show for it otherwise.

A parting thought you might appreciate. A saying I've modified to better suit my values.

I've traveled about a bit in my time of troubles I've known a few. But found it better in every clime to paddle my own canoe. My wants are few, I fret not at all for I've no debts coming due. I drive away strife in the ocean of life when I paddle my own canoe. Then tis love our neighbors as our selves if a better world we would travel to. And never sit down with a tear or a frown but paddle your own canoe. - I hope you, and Karen too, have many happy and satisfying days coming your way.

Oliver Cameron, Nenana, AK

Thank you, Oliver, for a great letter. I salute you and your lifestyle. Though you are some distance away we think of you as a good neighbor and friend at heart. KJS

COMPUTER CONCERNS

Dear Home Power: I am planning to move "off grid" in the next year, and am wondering if modern home computers can be run successfully (and reliably) off inverters and alternators. I would appreciate hearing from people with experience -- please include details on brands and models.

Charles Freeman, Ceres, CA

Please refer to John Osborne's articles in HP#'s 19 & 20 for more, Charles, this is apparently a popular subject. I am writing to you now on a Macintosh 512K, using power from our PVs through a Trace 2012 inverter. I have never had a power problem even with my Seikosha SP-1000AP printer. KJS Home Power issue 16 contains a compendium of computers and peripherals that run on inverters. RP

TRACKER HACKER

Dear HP, Good work folks! Here's my check for my renewal sub, I've been with you since HP#1. I'm an AE dinosaur who hasn't had to pay a PG&E bill for 18 years. This is a bad time of year for my

system tho. Due to the drought my 100 watt homemade hydro plant is down and the short days and cloudy weather don't do much for my 7 solar PV's. So it's back to kerosene sometimes, but I wouldn't have it any other way.

I have designed and built a solid state active tracker. The 4th prototype was finished this spring and has been working like a charm ever since. I use a linear actuator from a satellite dish, a few logic chips, 2 cadmium sulfate cells and a power Darlington 'H' bridge. I have a 5th prototype on the drawing board that will be much simpler, maybe you could put me in touch with people working on similar projects.

I built a Mark VI field controller for my hydro (HP#2) and was frustrated when it didn't work. After talking to Richard Perez, the designer, I learned that if you use an LM723 (V2) from the manufacturers, you must add a 1k resistor from PIN 11 (V2) to ground. It works fine now.

Also I remember reading a letter in HP (I can't find it now) from someone who said a Commodore C-64 computer could be run directly from 12 volts DC. This is true for all of the circuit EXCEPT for PIN 19, V2 and PIN 19, V1. Which require a 60 HZ square wave derived from the line frequency. A simple 555 timer could be used as a multivibrator to supply this signal which I believe is used for keyboard scanning. Thanks for a great publication!

Britt Webb, Box 225, Round Mtn, CA 96084

Wow, Britt, my brain got tired just reading your letter. Go for it! Keep up the ingenuity. Anyone interested in contacting Britt about his project may do so at the above address. KJS

STEREO HELL

Dear Richard, I am writing you in regards to our phone conversation last month concerning my trouble running my new stereo system. As you may recall, I had purchased a new Pioneer receiver(model #VSX-37005) and CD changer (model #PD-M430), and was attempting to run these on my Trace 2012 inverter. The CD changer worked fairly well on the inverter power. It did however require an external power switch to eliminate it as a phantom load and to prevent it from doing funny things when the inverter was in search mode.

The problem I encountered was with the receiver unit. This receiver contains a relay that disconnects the speakers from the amplifier during the first few seconds after the power is turned on. Apparently this is done to mute any noise that occurs as the unit warms up. On inverter power, this relay would not pick-up after the receiver had warmed up. The result was NO TUNES from my new system. I guess the Trace was generating too much noise in the amplifier and this was causing the speakers to stay muted. I tried everything I could think of to get around this problem, except dismantling the receiver, with no luck. I installed an isolation transformer, several R/C networks with various values, and an EMI filtering device containing an R/C network and inductor. None of these devices helped to alleviate the problem.

The final solution was to return the stereo system and buy an automotive stereo. I purchased the Pioneer model # KEH-M3000QR AM/FM cassette deck and a model #CDX-M50 CD changer. The AM/FM deck is designed to plug into the CD changer and control all of its functions. I connected these to my big old KLH speakers and tapped into our 12 volt system for power. The idle current consumption of these components is approximately 30 milliamperes. The running current varies, depending on volume, between .8 and 1.5 amps with 1.5 amps really kicking butt at the speakers. This system provides beautiful sound and most of the functions I would want in a home stereo. A similar Pioneer automotive system even comes with wireless remote control (more money!).

I enjoyed seeing you and Karen (and the rest of the crew) at SEER 90 and hope to see you there next year, if not sooner.

Sincerely, Dave Doty, 14702 33rd Ave. N.W., Gig Harbor, WA 98335

Sounds like you solved the problem admirably, Dave. Thanks for the recount. KJS. Hi, Dave, your experience parallels that of many HP readers. You still can't beat straight DC for low noise on audio/video gear. RP

MORE COMPUTING

Hello Readers of Home Power, I have been enjoying #'s 19 and 20 especially for the articles by John Osborne on computing with 12v energy systems. While not wishing to detract from his excellent work, I would like to point out another computer system that is compatible with us who use 12v solar or hydro set ups.

While living in the boondocks of Eastern Washington state (1983-85) off two 35w solar panels and 200 amp hours of battery storage, I got my first computer, a Commodore C-64 along with its 1541 disk drive and an old Gorilla Banana printer. A 9" color tv (12v) was used as the monitor. Believing that this set up MUST be run off 115 vac, I only used it when the 750w generator was alive, about 4-8 hours a week. Now anyone who has been bitten by the computer bug knows that THIS WILL NOT DO. To put the story short, I ended up using the system for several years off a 150 w inverter (Radio Shack, model unknown). The computer drive worked A-OK and printing was saved for those times the generator was on.

OK, now I live in the Seattle area and use the solar system over here to run the ham shack 100% on solar. 100 watts output, all bands, and the C-64 system for logging and other tasks; but now the C-64 is converted to 12v. Those interested in doing this conversion can find an article by John Neely (K6DYW) in the July 1990 issue of 73 Amateur Radio magazine. It only requires basic electronic skills and common sense. Cheap also, about $27 in my case.

Someone might say that the C-64 system is an old 8 bit machine without any potential. Bah! I also have a full blown 386 system here with all the latest software, but if the average person looks carefully at their needs verses wish-list, they will find the Commodore C-64, 1541 disk drive and a compatible printer will fulfill all their needs for less than $500, new. Berkeley Softworks offers word processing, spreadsheet, database manager, desktop publishing, educational, and other software in an operating environment similar to Apple's Macintosh or PCs with Microsoft's Windows for about $33 each mailorder. You run everything with inputs from a mouse, very little keyboard expertise is needed. Their trade name is GEOS. Dedicated programs of every subject are available for the more advanced user for fractions of the cost of major computer software.

OK, that's my bytes for now. My belief is in appropriate technology and to this end, the Commodore system is still used for letters like this and other events. My PC has its place also. Each computer has pros and cons and its purchase must be decided against your needs, now and into the future.

Bill Bowes-N7MOB, 412 N. Washington, #26, Kent, WA 98032

What a timely letter, Bill, and reminiscent for Bob-O and I, we started out on a C-64 with a Gorilla Banana on the side. Thanks for the input. KJS - KB6MPI

muddy roads

Mousie Wars II
Attack of the Wood Rats

Kathleen Jarschke-Schultze

We were well pleased with our new home. We had only been living there a couple of months and were enjoying the autumn weather. Because of my husband's asthma we still had no cats but did (and still do) have our dog, Amelia Airedale.

One morning Amelia became intensely interested in the bottom drawer of our antique wardrobe. Upon investigation Bob-O found not only the usual board games and cribbage cards but also about three pounds of dog kibble tucked between the boxes and playing pieces. The coup de grace was the six inch long rat tail protruding from the rodent's hiding place. He shut the drawer. It was early morning, and Bob-O had to drive his son to the school bus stop. The rat would have to wait

After he had gone Amelia continued to show fervent interest in the closed drawer. Afraid that she might scratch the finish in her eagerness, I opened the drawer again. No rat tail. Remembering the last time I had pulled out a drawer looking for a creature (Muddy Roads HP#12), I very carefully pulled the drawer all the way out. There he was! Amelia tried to get past me but was too slow. The rat darted behind the entertainment console. The rat was huge. I had never seen such a big rat.

Amelia stuck her head behind one edge of the console, the rat ran to the other end. Amelia dove around to that end. Back and forth they both went for several rounds while I stood there wondering what the heck to do. The rat decided before I could. It ran from the console to the open bottom of the wardrobe and on to the easy chair in the living room. I tried to tell Amelia she had lost her prey but she wouldn't listen. As I watched, horrified, it disappeared through a doorway into my kitchen.

By the time I got to the kitchen there was no sign or sound of the rat. When Bob-O got home I told him what had happened and we figured it had escaped outside somehow.

The next day, while Bob-O was outside and I was in the kitchen I heard a soft tinkling sound from the refrigerator, as if someone were cleaning the cooling coils. I just knew it was that rat. When Bob-O came inside I had him listen too, but no noise happened. Every time I heard it I would get Bob-O and make him listen, but to no avail.

Finally he said, "That's it, we're gonna take the back off the refrigerator."

So it ended up with me standing on a chair (I didn't want that huge rat running up my legs) ready to pull the back off the refrigerator. We had every cookie sheet in the house blocking the doorways and Bob-O had his pistol with snake shot in it.

I had barely begun to pull off the backing when the rat ran out and across Bob–O's feet towards the door. He was startled but got off a shot. He missed (you can see a dark patch of duct tape on floor of our kitchen on back cover of HP #20). The rat ducked into the stove. We took the burner grids and trays off and there he was along with two apples, a plum and more dog kibble. Bob-O shot him and we buried him.

I found the whole episode distasteful. Soon after that I discovered a wood rat in my greenhouse. He had eaten most of my succulent plants and some rose cuttings. On our next trip to town I bought a HavaHart trap.

That night I made up some tempting rat sushi. I took a small apple, cut it in half, scooped out the center with a melon baller and put in a dog kibble. It proved irresistible. The next morning I had the rat caught. He didn't look happy at all but he had eaten the sushi. I took him, enclosed in the trap, for a little drive of about five miles and released him in the woods. He has not returned. I am gratified.

Now there is a skunk living under our house and we don't have a rodent problem anymore. We just have to bathe Amelia in tomato juice once in a while.

Above: Amelia Airedale, a distinguished veteran of the Mousie Wars.

Ozonal Notes

Biggest Home Power Ever!

We hope you enjoy this issue and find it useful. We sure had fun putting it together. At one hundred pages, this is the largest issue of Home Power ever!

The Green Dream Is Working

For example, in this issue you will find James Davenport's report on his home-made PV–powered refrigerator/freezer. James got the idea from an article by Bob McCormick in HP#16. Now less than eight months later, Jim has constructed his refrigerator and written an expanded article on its construction. It is happening! The information is circulating. Those trucking the info are adding their experiences and sending it around again. And each time the information circulates it becomes more complete, more detailed, and more useful. This is the reason that we started publishing HP. We are overjoyed that the concept is working. We salute all Home Power readers. You are making this happen!

Home Power Hits Newsstands World Wide!

Home Power Magazine is now being distributed by eight major magazine distributors. This means that this copy of HP will appear in hundreds of book and magazine stores all around the world. We're serious about spreading the word about renewable energy. To this end, if you know of a store in your area that should be carrying Home Power, then let us know.

War On Schedule

It was hard to keep working on this issue with the world gone nuts again. Another war, just what we need. We haven't shut off the TV set for more than a few minutes in the last two weeks. The macabre video is as fascinating as a car wreck. While one is appalled, one must keep looking. There but for fortune…

The television coverage of the Gulf War is giving us a new look at what war really is like. Pain, death, destruction, and, most of all, complete confusion served up on the hour with glitzy graphics.

Regardless of your political persuasion, I think we can agree that the Gulf War is really the Oil War. While many true and noble reasons can be cited for squashing Saddam Hussein like a bug, the reality is that our oil bucks bought him his death toys.

I've seen four major wars during my forty-six years. This is the first one where one side picks up all the bills for both sides.

The real tragedy of the Gulf War is that it was avoidable. We didn't have to buy it. Our insatiable lust for oil leads us to deal with the lowest slime imaginable. We should not be surprised when our dollars turn around and bite us.

Ironically, we'd rather fight than switch. The sooner we realize that only renewable energy sources offer us any future at all, the sooner we can stop killing each other over a foul and polluting liquid.

Enough, I'm climbing down from my soap-box. Thanks for listening to something that I **had** to say.

Richard & Karen

Writing for Home Power Magazine

Home Power specializes in hands-on, practical information about small-scale renewable energy production and use. We try to present technical material in an easy to understand and easy to use format. If you want to contribute info to Home Power, then here's how it is done…

Informational Content

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Home Power articles can be between 500 and 10,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short and to the point. We like the generous use of **Sub-Headings** to organize the information. We highly recommend writing from within an *outline*. Check out articles printed in Home Power. After you've studied a few, you will get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

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We can work from any color or black & white photographic print. We can work from a negative if necessary. If your photo is for the color cover, then the best results are obtained with a color transparency (color slide).

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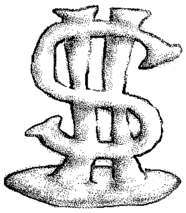
RP



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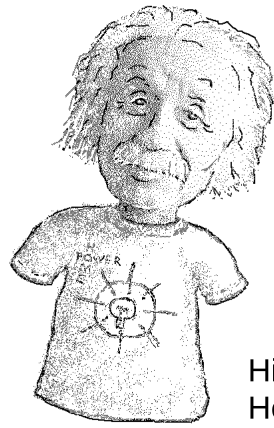

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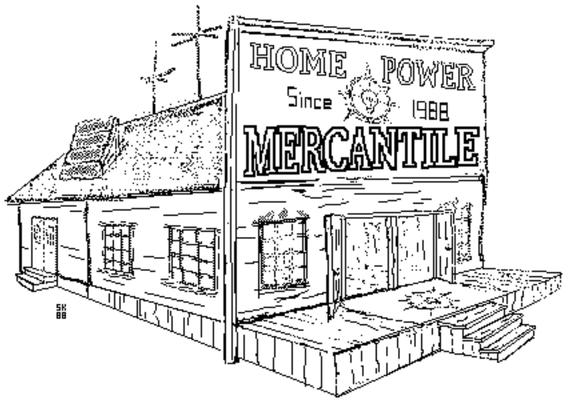

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